

SCIENTIFIC REPORTS

OF THE

Imperial Agricultural Research Institute, New Delhi

For the year ending 30th June 1940



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of the
IMPERIAL AGRICULTURAL RESEARCH INSTITUTE
NEW DELHI
for
the year ending June 30, 1940

REPORT OF THE DIRECTOR

(B. VISWA NATH)

I. INTRODUCTORY AND GENERAL

This is the fourth report after the transfer of the Institute from Pusa to New Delhi in the year 1936, and the third report after commencing growing of crops on the Delhi Farm.

Judging from the comparison of yields of crops at the Delhi farm in 1936-37, with those on the farm at Pusa, it was observed in an earlier report that, although the land at Delhi suffered severe levelling and the consequent displacement of even two or three feet of the top soil, the land showed markedly rapid recuperative powers. This is further supported by the increase in yields in subsequent years as can be seen from the yields of oats in plots Nos. 1, 2 and 3.

Main Block	Yield of oats per acre in maunds		
Plot No.	1936-37	1938-39	1939-40
1	18·78	27·34	31·67
2	23·94	29·07	35·00
3	20·30	27·79	32·15

At the Sub-station of the Institute at Karnal the season was distinctly unfavourable, and the rainfall during the year under report was only 13·91 inches as against 21·36 inches in the previous year and 23·35 inches in 1937-38. The improvements in the drainage system of the Karnal farm enabled the introduction of improvements in agronomy, and the effect of poor rainfall was not apparent on the yield of most of the crops. An outturn even better than in the previous year was obtained in some crops.

During the year, the Institute suffered loss, through retirement on superannuation or preparatory to superannuation, of four of its able and experienced officers, *viz.*, Mr. Wynne Sayer, Mr. N. V. Joshi, Rai Sahib Kashi Ram and Mr. S. M. Jamaluddin. The first three officers were among what may be called the "foundation officers" of the Institute, having joined the Institute almost immediately after its establishment, and made valuable and enduring contributions in their respective fields of research and investigation. Mr. Sayer's work in the field of cattle-breeding and management and in mixed farming is unique. His achievements with the famous herd of pedigree Sahiwal cows are outstanding examples of his contributions to animal husbandry. Mr. Joshi is a pioneer worker in the field of agricultural bacteriology in India and has made many original and enduring contributions to the microbiology of Indian soils and to the subject of bacterial diseases of crops. Rai Sahib Kashi Ram, who started his career with the Howards in the Plant Breeding Section, contributed in no small measure to the introduction and development of the cultivation and curing of cigarette tobacco in India. It was he who first made suitable modifications and successfully worked in India barns for the flue-curing of Virginian tobacco.

As a central organisation, the functions of the Institute are to carry out research and post-graduate instruction in the different branches of agricultural science. Steady progress was made in these directions and the standard continues to be at the highest level. The post-graduate courses are becoming increasingly popular. Highly qualified students sought admission to the post-graduate courses in much larger numbers than there was hostel and laboratory accommodation. The facilities offered at the Institute continued to attract research workers in increasing numbers. There was marked expansion in the activities of the different Sections of the Institute on the research and advisory sides. The modest expansion scheme which was approved towards the end of last year received financial sanction towards the end of the year under review. This enabled further expansion of activities and commencement of new lines of study. The progress of work during the year under report will be briefly reviewed here. Details will be found in the reports of the Heads of Sections which are printed as a continuation to this review. The scientific papers published are listed in Appendix III (pp.125-126).

II. RESEARCH AND INVESTIGATION

1. MIXED FARMING—CROP AND ANIMAL HUSBANDRY

The investigations on mixed farming are designed to study theoretical and practical aspects of building up and maintaining soil fertility, which is the main link between land and live-stock. The lines of work consisted of (1) experiments in crop husbandry to secure improvement in crop yields in large and small scale farming by suitable crop rotations and growing of fodder crops, and (2) experiments in animal husbandry towards improvement in live-stock and milk production, so that the land and animals maintain each other and still leave a margin.

(a) *Crop Husbandry*

The grain and fodder unit at Delhi, which consisted of an area of 307·28 acres, was worked according to the three systems of crop rotation mentioned in last year's report. The production of grain and dry and green fodder from this area in the *kharif* (hot season) of 1939 and the *rabi* (cold season) of 1939-40 was just enough for the feeding of 287 head of dairy herd and work cattle. Green fodder was surplus by 4,164 maunds while grain and dry fodder were deficient by 698 maunds and 102 maunds respectively.

Mixed farming experiment on the small scale.—An experiment was started in the 1938-39 season to study the working of a small unit of $7\frac{1}{2}$ acres with irrigation facilities. The unit has been designed to maintain two bullocks, one milch animal with one or two young stock. The scheme provides for using the manure for the land and for different crop rotations. The four-year rotation consists of maize-peas-cotton-sugarcane-fallow-wheat; the three-year rotation provides for *jowar*-gram-fallow-wheat-green manure-wheat; while the two-year rotation consists of cotton-fallow-barley. The details of the rotations will be found in the report of the Imperial Agriculturist.

Long term rotation experiments at Pusa.—The records of long-term rotation experiments carried out at Pusa for 18 years over an area of 413 acres, as part of the mixed farming project, were under collation and the average yields per acre for the different crops in the rotation in successive years was worked out. The rotation followed was a three-year six-course rotation on the following lines:

	1st year	2nd year	3rd year
Monsoon crop (<i>kharif</i>)	Maize for fodder	Maize for grain	Green pulses for grazing.
Winter crop (<i>Rabi</i>)	Oats	Arhar (<i>Cajanus</i>)	Oats.

Manuring was done with farmyard manure at ten tons per acre or oil-cake to give equivalent amount of nitrogen in the first year before sowing maize and with double super-phosphate at one maund per acre in the third year before sowing oats. Judging from the yields of crops in successive years, the rotation and treatment improved and maintained the fertility of the soil.

Investigations on the cultivation of fodder crops and grasses.—The investigations started at Delhi and Karnal to ascertain the number of cuttings that can be taken without decreasing the quantity of seed obtained from berseem crop were continued. The results of three years' experiments at both the stations show that the maximum quantity of seed is obtained after the third cut in February. In regard to irrigation experiments to determine the optimum interval between two irrigations, the results show no significant differences in the yield of fodder from plots irrigated once in 8, 10 and 12 days on the loamy soil at Delhi. This would result in a distinct saving in irrigation water and the consequent reduction in the cost of production of fodder and seed.

The experiment with cold weather fodder crops to test their relative yields gave interesting and unexpected results with berseem. The area that was under cold weather fodder crops in the season 1938-39 was sown with maize in the *kharif* of 1939, to test the comparative nitrogen enriching powers of the different fodder crops of the previous season. *Senji* (*Melilotus* sp.), *methra* (*Phaseolus* sp.), *kerao* (Peas) and *khesari* (*Lathyrus* sp.) were harvested in January and February, and the plots remained fallow till maize was sown in mid-June, while berseem was harvested towards the end of May, and maize was sown in the plot in the middle of June. Under these conditions, berseem did not show its beneficial effect on the soil and the yield of maize was 76.5 per cent. of the general mean. The poor yield of maize fodder after berseem was suspected to be due to the short fallow and this was under test. The results on the *kharif* maize following the *rabi* fodders will be available next year.

Comparative studies on cold weather fodder crops.—The crops under this study were berseem, *methra* (*Phaseolus* sp.) *kerao* (peas), *senji* (*Melilotus* sp.), *khesari* (*Lathyrus* sp.). Berseem gave the largest yield of fodder, being longest in the field. The yields of other fodders ranged between sixty and seventy per cent. of the yield of berseem. In regard to water consumption, as judged from the quantity of irrigation water used per hundreded pounds of green fodder produced, berseem, *methra* and *senji* required three times the amount of water consumed by *kerao* and *khesari*.

Comparative trials with grasses.—The following grasses were under comparative trial :—

- 1 Anjan (*Pennisetum cenchroides*)
- 2 Palwal jerga (*Andropogon ischaemum*)
- 3 Dub (*Cynodon dactylon*)
- 4 Guinea grass
- 5 Elephant grass
- 6 Rhodes grass
- 7 Bara-jerga (*Andropogon annulatus*)
- 8 Goroya (*Andropogon menticola*)
- 9 Chhoti-jerga (*Andropogon pertusus*)
- 10 Murjhain (*A. favoelatus*)
- 11 Sudan grass.

The first three did not grow well under cultivation. Guinea grass remained stunted in growth during winter, but gave three cuttings in summer and was relished by cattle. Elephant grass remained dormant in winter but gave very good yield during the year. The *Andropogons* when grown from seed showed no inclination to grow during the cold weather, but with the advent of summer picked up. Sudan grass grew fairly well but milch cows did not appear to relish it.

Manurial experiments.—Comparative preliminary experiments to test the relative merits of farmyard manure, activated sludge, compost, rape cake and a complete mixture of artificial fertilisers were laid. The manures were applied to maize in the *kharif* season and barley was grown in the *rabi* season without further application of manure. There were twelve treatments in randomised blocks with six replications. On equivalent nitrogen basis the largest increase (31 per cent.) over “no manure” was obtained from plots receiving a mixture of farmyard manure and artificials, closely followed by “complete fertiliser” plots. A mixture of compost *plus* artificials, activated sludge alone and rape cake alone formed the next highest group with an increase of 15 per cent. over control.

The sub-station at Karnal being principally under power-farming, work was commenced on large-scale composting of farm wastes. Fifteen thousand eight hundred and two maunds of compost were made during the year under report and the cost of making the compost, including the expenses for carting, worked out to just a little over half an anna per maund.

Experiments with paddy on the relative merits of sulphate of ammonia and a mixture of sulphate of ammonia *plus* nitrate of soda were concluded during the year. Sulphate of ammonia gave as good results as the mixture.

(b) *Animal Husbandry*

The Sahiwal herd consisted of 214 head and the Tharparkar of 236 head at the end of the year. The average milk yield of the Sahiwal herd per cow per day was 21·9 as against 21·2 lb. in 1938-39; that of the Tharparkar herd was 19·6 lb. as against 19·2 lb. in 1938-39. In the Sahiwal herd the performance of two cows Laruli and Bilamba was 11,046 lb. and 10,004 lb. of yield of milk respectively in 306 days. Six cows yielded between 8,000 and 9,000 pounds of milk and four cows yielded between 7,000 and 8,000 pounds of milk over a lactation period of 306 days. In the Tharparkar herd at Karnal, Machkani and Kumari yielded 9,000 and 10,000 pounds respectively during a lactation period of 305 days and four cows yielded between 7,000 and 8,000 pounds.

Early maturity experiments.—In the beginning, investigations were conducted by mating heifers which reached maturity between thirteen months and two years of age; subsequently experiments were carried out to fix a standard for early maturity age for mating purposes. The results suggested that early mating age should be in relation to a definite body weight. In the light of these findings, experiments were set on foot two and a half years ago to find out a standard size which would be in direct relation to early maturity age, and that weight was found to be two-thirds of the normal adult body weight of the animal. The average standard body weight of a Sahiwal cow is 900 lb., and therefore the weight for heifers on reaching maturity is 600 lb. The standard weight for mating heifers was used irrespective of any earlier age, and the calves born during the year from such matings had normal calf weight and their growth was not in any way affected during the gestation

period. Nor did the heifers show any inability in developing and throwing calves of average size. Twenty-eight heifers calved down during the second half of the year and many of them had already yielded over 3,000 lb. of milk in about half the lactation period, and their average daily milk yield at the end of the year under review was as high as 24 lb. per heifer per day. For deciding early maturity and for mating, we have now a standard which balances age, weight and constitution.

The influence of season of mating on the sex of calves.—The data that have accumulated during the last thirty years were under collation and examination. On an analysis of the sex of calves born during the last thirty-six years, a tendency towards a higher percentage of bull-calves was observed in winter and autumn, while in summer and spring the percentage of bull-calves and heifer-calves was equal.

Seasons of birth	1904-40		1938-39		1939-40	
	Bull calf Per cent.	Cow calf Per cent.	Bull calf Per cent.	Cow calf Per cent.	Bull calf Per cent.	Cow calf Per cent.
Winter . .	52.8	47.2	57.1	42.8	53.3	46.6
Spring . .	50.8	49.1	50.0	50.0	57.1	42.8
Summer . .	50.0	50.0	22.2	77.7	50.0	50.0
Autumn . .	51.6	48.6	57.1	42.8	69.2	30.7
Average .	51.4	48.3	50.0	50.0	56.4	43.6

Sale of cattle.—The high demand for our cattle continued in India and outside India, viz., Kenya, Jamaica and Costa Rica. Sixteen cows, two bulls and twenty-one young bulls were sold during the year under report.

2. CROP IMPROVEMENT

(a) Sugarcane

Sugarcane breeding.—The aims of breeding at the Coimbatore Station are getting increasingly specialised. Besides breeding for 'early' and 'late' canes, their reaction to pests and diseases is receiving attention in the selection of parents for crossing. The transmission of rind hardness by *S. spontaneum* employed as parent is being studied as of possible ultimate use in the breeding of resistant types. Two further types of *S. spontaneum* from U. S. S. R. and Mauritius were secured.

The number of popular Coimbatore canes are now so numerous and their performance in various parts of India so well known that they are playing a steadily increasing role as parents at the station. The demarcation line between the so-called 'medium' and 'thick or noble' types is getting fainter. This is because of the wider range of climatic and soil conditions which the new productions are able to tolerate as the direct result of the range and nicety with which the parents are selected for crossing.

One handicap to sugarcane breeding has been the disparity between the times of flowering of parents desired to cross with each other. During the year useful results were obtained for bridging this time gap through different lines of investigation. Extra illumination of the parents Co. 285 and Co. 241 delayed their flowering by about a fortnight. Topping of canes during growth gave the same result but the arrows were much reduced in size. By fitting a special arrangement to the ordinary thermos flask for controlling temperatures and humidity inside, it has been possible to preserve cane pollen in viable condition from 14 to 20 days depending upon the variety.

Inheritance studies on sugarcane $\times$ bamboo hybrids revealed in the hybrids a certain number of anatomical characters definitely attributable to the bamboo parent and sometimes not available within the genus *Saccharum*. The analyses of characters brought out the dominating influence of the *Saccharum* mother parent in these hybrids.

Young stems of bamboo when crushed in the sugarcane mill recorded as much as 5.2 per cent. sucrose in juice which is higher than that found in certain of the wild *Saccharums*. Juice analyses of certain of the bamboo hybrids showed obvious influence of the bamboo parent in their starch, inulin and galactin contents.

In the breeding of thick canes, Co. 440 promises to replace P. O. J. 2725 for evolving 'early' and 'rich' types. Cos. 419 and 421 are being increasingly used as parents as they give good germination and vigorous seedlings. Further combinations were made between the thick and medium Co. canes with promising results.

(b) *Crops other than sugarcane*

In wheat further progress was made in the evolution of varieties possessing disease resistance and other desirable characters. Breeding for rust-resistance was continued at the sub-station at Simla with the co-operation of Dr. K. C. Mehta, and the F_5 generation of nine crosses between resistant foreign varieties and important Indian ones were studied this year. Out of 2,794 seedlings tested with mixtures of all physiological races of the three rusts occurring in India, 1694 proved resistant. A complex cross was also made with the object of synthesising high resistance to all the three wheat rusts into a single variety. Another study has been undertaken at Simla with the object of correlating rust resistance with easily determinable morphological and other characters such as the time of opening of the stomata and the relative proportions and disposition of schlorenchyma and chlorenchyma in the culm.

Co-operative experiments were carried out with the Section of Mycology and Plant Pathology to test the resistance or susceptibility of a large number of wheat varieties to loose smut and flag smut.

Breeding work for the production of non-shedding strains of I. P. 114 and I. P. 120 wheats has resulted in the isolation of three selections from the

latter type which are not only non-shedding but were also highly resistant to yellow rust.

Two hundred and sixty varieties of wheat, both Indian and foreign, were grown under dry conditions to test their ability to withstand drought. The trial will be repeated next year.

In regard to pulse crops, a number of F_4 families of pigeon peas from the cross I. P. 24 X I. P. 51 and its reciprocal grown at Pusa under wilt-infested soil conditions showed a high degree of resistance to *Fusarium* wilt combined with high yields, bold grain size and desirable cooking qualities.

The genetical studies of the tiny-leaved mutant and the simple-leaved mutant in gram were completed, and it was concluded that these mutant characters were recessive to their respective normals, but that the latter character was subject to frequent reversals owing to the instability of the genes governing it.

Among oil-seeds, breeding for rust-resistance in linseed was continued and resistance or susceptibility was tested out at Delhi and Karnal in 160 F_6 families of crosses between susceptible indigenous varieties and resistant exotic strains.

Breeding of disease-resistant types of potatoes was continued at Delhi and Simla. A number of hybrids derived from crosses between Indian and imported varieties have shown high yielding capacity and are relatively resistant to diseases under Simla conditions. The seed material of these will be improved and trials will be carried out in the provinces at various centres of potato cultivation.

Cytogenetical investigations.—In an attempt to formulate a cyto-taxonomic classification of the Brassicæ group, an all-India collection of species and varieties was under study both with regard to their morphological characters and chromosome numbers. Several plants from one culture raised from seeds received from the North-West Frontier Province were found to contain $2n=38$ chromosomes, a number not reported in any of the cultivated Brassicæ in India. These plants may belong to the European species *B. napus*.

The F_3 s of a number of intergeneric and interspecific hybrids were under study. The occurrence of pseudogamy in interspecific crosses of Brassicæ and in the intergeneric crosses between *B. nigra* ($2n=16$) and *Nasturtium* sp. ($2n=16$) was noticed. This phenomenon was quite marked in the intergeneric crosses, and embryological studies to ascertain its mode of origin were under way. In the cross between *B. campestris* X *B. juncea* a triploid hybrid with twice the maternal chromosomes was obtained. One hybrid plant obtained from each of *B. nigra* X *B. campestris* and *Brassica* sp. X *B. campestris* proved absolutely sterile owing to partial or complete failure of pairing between the parental chromosomes at meiosis. The hybrid obtained from the former cross was similar in cytological behaviour to that of the haploid *rai* isolated last year; this observation is significant in connection with the

study of the origin of *B. juncea* which is supposed to have arisen through interspecific hybridisation of *B. campestris* ($2n=10$) and *B. nigra* ($2n=8$) followed by chromosome doubling in the sterile hybrid. Hybrids between the 10—chromosome species showed inversion hybrids at Metaphase I and II.

The study of the genetics of the three mutations, *viz.*, apetalous mutant in *Sarson*, 'closed petal' mutant in *toria* and male sterile mutant in *termaria* was continued and in every case the mutant character was found to be a recessive in the F_1 generation.

Further progress in the study of the inheritance of self-sterility was made and an interesting self-fertile mutant plant of *toria* was obtained. Spontaneously occurring autopolyploids and those induced by colchicine treatment were under study.

Two tetraploid plants in pigeon-pea, two triploids in *toria* and one triploid in *Nicotiana Goodspeedii* were isolated for the first time and studied cytologically.

From these and other studies, evidence was obtained that colchicine, also induces, besides polyploidy mutations and chromosome rearrangements without the duplication of chromosomes.

(c) Seed supply

About 3,500 mds. of pure seed of various crops bred at the Institute and its Sub-stations were distributed during the year to a large number of agricultural officers and private individuals in India. The supply included about 1,200 mds. of wheat, 1,000 Mds. each of oats and gram and 300 mds. of other crops.

3. SOIL INVESTIGATIONS

The data collected in the investigations on the biological control of sugarcane borers by *Trichogramma* formed the basis for developing a sampling method which would reduce variance to the minimum possible, for the percentages calculated from the observed sample. The analysis of the data has shown that the variances for sampling units of one acre and two acres are considerably less than those for row sampling units.

The data obtained from the uniformity trials with wheat, were further examined to secure more information on the efficiency of balanced and randomised arrangements in field plot technique. Balanced arrangement has not given greater residual variance than randomised arrangements.

The method of analysis of experiments involving three and four restrictions was investigated and a suitable method was worked out. The sum of squares calculated in the usual manner is orthogonal to each other for only two restrictions; others are not independent of the first two restrictions and hence corrections are necessary in evaluating the sum of squares due to the additional restrictions.

Further progress was made in the preparation of soil maps in relation to soil types and climatic factors to bring out the effect of the type of climate on different types of soil. Maps showing the relationship between soil type, climate, and the major crops were also prepared to show zonal classification of crops and their soils in reference to the character of the bioclimate obtaining in that zone. This type of mapping is important in bringing together the dominant factors of soils under one co-ordinated system of major and minor groups of soil and in distinguishing crop adaptation and development in relation to soil type and climate. It is hoped that by this method of approach to the study of the mature soils and the old established farming systems, it is possible that many conflicting, or unused and seemingly unrelated, data would acquire new significance, and will provide new information as interesting from the scientific point of view as it will be important to practical agriculture.

From considerations as mentioned above and on the basis that soil is the visible expression of the geobiological, bio-climatic and agro-biological forces operating on it, studies have been in progress on the relationship between climate and soil processes on the one hand, and on the relationship between soil properties and soil formation processes on the other.

The work of the past two years related to the analyses of clays separated from surface soils and the then discussion was based on the progress of work so far. During the year under report the study was extended to clay fractions separated from lower depths down to five feet, at one foot intervals or on horizon basis. The new additional data corroborate the results and conclusions of the two previous years, and are helpful in arriving at a system of classification of Indian soils into broad zones and in determining the characteristics of the soils and their profiles with reference to a zone and in reference to the transition changes from one zone to another.

4. FERTILISERS, MANURES AND PLANT NUTRITION

Work on manurial and fertiliser problems consisted chiefly in the study of the methods for the making and storage of farmyard manure and on the conversion of sewage into an innocuous sludge manure by the activated sludge process.

In spite of all reasonable care consistent with economy of labour and expense the daily collection of dung and litter and the making of farmyard manure according to the usual methods encourages fly-breeding, especially in the hot season. The methods at present in use are aerobic in principle as the heaps of dung and litter are left exposed. In the initial stages the material attracts flies, and the daily dumpings and the temperature attained as the result of aerobic fermentation do not prevent the hatching of eggs and the development of maggots, which can burrow up their way and develop into flies. Preliminary laboratory studies were started to find out if anaerobic fermentation can be applied without loss of manurial constituents. At first bacterial seed-beds were established and trials were made

with straw, dry leaves, dry sludge, farm litter and other materials. The evolved gases were analysed. Their composition was nearly the same for the different types of waste materials employed. All the nitrogen of the fermented material was conserved in the seed-bed.

The activated sludge plant at the Institute has been installed for the disposal of the sewage of the estate. It is also an equipment for the scientific study of the whole question of converting waste products like sewage and night soil into a fertiliser. If this is satisfactorily and economically achieved in India it would remove the prejudice against these sources of organic manure. The lines of research are the study of (1) the quickest way to produce maximum decomposition and sludge, (2) the fertilising value of sludge in comparison to other organic manures, (3) the economics of the whole system, (4) the influence of the sludge manure on the growth and composition of crops and their quality. Valuable preliminary data have been obtained both on the conversion of sewage and night soil into manure and on its manurial value compared with farmyard manure and oil-cake. Mention has already been made of the results of manurial experiments, and the other results will be discussed in greater detail in future reports.

The work on the effect of manurial and environmental factors was continued during the year. Wheat grain (I. P. 52) grown under different manurial treatments was analysed for proteins and their extractability, by different solvents, for ash and for phosphorous and calcium. The differences in the above constituents in the wheats grown with farmyard manure and with mineral fertilisers did not show appreciable difference, but green-manured wheat increased appreciably in all the protein fractions except glutelin. During the year investigations were also carried out on eight types of I. P. wheats grown in the same year at Pusa, Delhi and Karnal. As would be expected, there were considerable differences in composition due to varieties, but environment would appear to induce equally wide differences. The results available so far point to considerable variations in the protein complex of the wheats under different environments.

The work that has been in progress for some years now on the effect of manures, particularly organic manures, has provided more and more evidence on the effect of manures on the quality of crops. At the present moment there are two distinct and opposing views in regard to the effect of organic matter and organic manures on crops. One school holds that the action of organic manures lies in promoting an even and regular course of growth, smoothing out seasonal variations in water and nutrients. The other school considers that organic manures do this and more by way of supplying certain factors different from the usual fertiliser elements and thus promoting normal metabolism in plants.

Irrespective of the rights or wrongs of these views, the experience of the two schools should, however, find the greatest common agreement in the statement that, under critical conditions, organic matter and organic manures generally contribute to better yields both in quantity and quality. The

critical conditions are (1) hot dry periods when soil moisture falls very low, (2) soils containing harmful quantities of soluble salts, (3) soils where texture is all important, (4) soils deficient in organic matter and/or in one or more of the minor elements. Many Indian soils are deficient in organic matter and are subject to varying periods of continuous moisture deficiency occasioned by limited monsoon period and the erratic nature of the monsoon, and it is here that field factors need investigation. Crop production depends on soil fertility, and organic matter and organic manures are necessary to build up and maintain soil fertility, and it is on this that artificial fertilisers bring about maximum of yield and quality. The practical problem therefore is the determination of the minimum quantity of organic manure necessary to provide quality, and then to ascertain what more is necessary for maintaining texture, fertility of the soil and for securing optimum yield.

5. INVESTIGATIONS ON AGRICULTURAL PRODUCE AND INDUSTRIES

Sugarcane and gur investigations.—The work on active carbon manufacture and *gur* production continued to progress and covered a large scale economic production of active carbon and its use in the manufacture of *gur*. The results are expected to be published by the United Provinces authorities and will be of very great significance in advancing the use of the active carbon process of *gur* manufacture as an economic proposition.

Malting qualities of barley.—At the instance of the Agricultural Marketing Adviser to the Government of India and in co-operation with the United Provinces Department of Agriculture, malting tests of barleys grown in the United Provinces were carried out on the same lines as those followed at the Institute of Brewing in London. The tests showed that the same variety grown in different districts produces malt of widely varying quality. Owing to small number of samples, it is not possible to correlate soil and climatic factors with malting values, but the data strongly suggest that certain districts can produce barleys of better malting quality than others. Generally, the samples were of high quality and malted well.

6. PESTS AND DISEASES OF CROPS

Pests.—Ecological work on the spotted bollworm on cotton (*Earias fabia*) and its important parasite was continued. Under a S. D. of 3 mm., the optimum temperature for oviposition by *E. fabia* was 25-30°C. A temperature of 35°C., during the entire life of the insect, caused marked sterility, but was not so injurious when the influence of temperature was on the pre or post-imaginal stage alone. The duration of the adult life was found to decrease with the increase of temperature. Although *Earias* spp. are the favourite hosts of *Microbracon lefroyi*, it would appear that the latter have an acceptable alternative host in the pink bollworm (*Platyedra gossypiella*) during the off-season. A temperature of 20°C. was found to be the most

suitable for the egg-laying activities of this parasite, but humidity between saturation deficiencies 0 and 3 mm. had no effect either on its longevity or fecundity.

Studies on the effect of high temperature on the pink bollworm during the year showed that exposure of naked larvae for about 24-30 hours to 45°C. for 1-1½ hours to 50°C., for 7-10 minutes to 55°C., for 5 minutes to 60°C. for 2-3 minutes to 65°C. and for 1 minute to 70°C. was found to be fatal. To kill larvæ inside "double seeds", however, exposure of over 3 hours to 50°C., of 40 minutes to 55°C., of 15 minutes to 60°C., of 7-10 minutes to 65°C. and for 2-3 minutes to 70°C. was found necessary.

Further studies on the leaf-curl disease of tobacco at Pusa showed that for the white-fly *Bemesia gossypiperda* the alternate hosts of the leaf-curl disease of tobacco are numerous. Efforts to control the white-fly population in tobacco nurseries by dusting and spraying resulted in a considerable decrease in the incidence of the leaf-curl disease. The white-fly has been observed to be most common in tobacco fields in autumn when the incidence of the disease is also very high.

Work on the preparation and maintenance of complete records of parasites and predators attacking various pests in different parts of India, was continued. During the year under report, systematic revision of the Chalcidoid families, Agaonidæ and Torymidæ was completed, and data on the biology, hosts and distribution of Serphoidea and Bethyloidea were collected. A systematic examination of the Indian species of *Microbracon* and some allied genera clarified the identity of many forms and resulted in reducing the number of Indian species of this genus to less than a dozen. The Braconid, *Apanteles flavipes*, is found to be a fairly common species in the country parasitising such well-known pests as *Chilo zonellus* and *Argyria sticticraspis*.

With the coming of new areas under cultivation on the estate, the hairy caterpillar (*Amsacta moorei*) appeared as a very serious pest of several *kharij* crops. During the last monsoon the work of destruction of all stages of this insect was organised on field scale and damage to crops under an area of about 300 acres was subsequently avoided. The use of light traps successfully employed by the Punjab Department of Agriculture proved most effective in this work.

The fly trap devised by the Entomological Section has now fully established itself as a cheap and effective appliance, capable of being used on large scale for the control of flies, and is already in use by several government and municipal bodies.

Studies on the insect pests of sugarcane were continued at New Delhi and at the Sub-stations at Karnal, Pusa, and Coimbatore, and included the major pests, *viz.*, root, stem and top borers and *Pyrilla*.

At New Delhi, *Saccharum ravennae* Linn., a wild grass growing in plenty round about the Imperial Agricultural Research Institute, was found to be

an alternate host plant of *Scirpophaga nivella* F., *Sesamia uniformis* Ddgn., and *Emmalocera depressella* Swinh.

The incidence of pests at Karnal on five selected varieties of sugarcane, viz., Co. 285, Co. 312, Co. 313, Co. 331 and Co. 421, was noted during the growth of the crop and at harvest time. Co. 331, Co. 421, and Co. 285 showed less attack by *Scirpophaga nivella* F. than Co. 313 and Co. 312. In the case of *Emmalocera depressella* Swinh, the five varieties can be grouped as follows regarding varietal susceptibility; Co. 285, Co. 331 = Co. 312, Co. 313 = Co. 421. At Pusa the incidence of pests on Co. 331 and Co. 210 during the growth of the crop and at harvest time showed that the percentage of canes attacked by *Scirpophaga nivella* F. was less in Co. 331 than in Co. 210.

Studies on the incidence of borers under different conditions of planting were started in Meerut and Bhopal with the co-operation of the authorities concerned. In Meerut the variety Co. 312 was planted according to two methods, viz., (i) the Java method of planting cane setts in deep trenches, and (ii) the local flat method of planting cane setts in furrows 2 inches deep. In Bhopal, varieties Co. 244 and Co. 421 were planted according to three methods of planting, viz., (i) the Java method in deep trenches, (ii) Deep furrow method, and (iii) Mysore method.

The investigation of the sugarcane leaf-mid-rib in relation to resistance of cane shoot to the top-borer, (*Scirpophaga nivella* F.) was continued in the field and in the laboratory, and further information was obtained. At Bhopal, during October 1939, Co. 404, which has a soft mid-rib, was the most badly attacked. Co. 331 and Co. 421, both with a rather hard mid-rib, showed a good resistance to the top-borer. At Pusa, during November 1939, the incidence of the top-borer in Co. 432 and Co. 356, both with a rather hard mid-rib, was 16.5 and 16.6 per cent. respectively, compared to 43.5 per cent. attack in Co. 508 which has a rather soft mid-rib. At Sardarnagar (near Gorakhpur), during February 1940, the incidence of the top-shoot-borer in Co. 421 and Co. 432 both with hard mid-ribs was 48 and 8 per cent. respectively as compared with 60 and 87 per cent. attack in Co. 419 and Co. 290 with soft mid-ribs.

At Coimbatore, during March 1940, mid-rib sections of certain varieties of sugarcane were studied with the help of the Sugarcane Expert. It was seen that the varieties found in the field to be resistant to the top-borer, when compared to more susceptible varieties, had more lignin towards the outer surface of the mid-rib, making it more difficult for the larva of the top-borer to bite into the mid-rib.

The habits and structure of first and second instar larvæ of *Scirpophaga nivella* F. were under study because it is the first instar larva that gets into the shoots, and the larva is unable to leave the first shoot it has entered and get into another shoot. The first instar larva is very active, crawling about with great ease on any part of the plant. The second stage larva is a very sluggish creature with thick abdominal segments. When once removed from the shoot, it is not able to bite through and enter it again. It is unable

to move about except in its burrow which was started in its first instar stage.

In addition to breeding some new parasites in the laboratory, the bionomics of the important parasites and predators were studied. The larva of *Epipyrops melanoleuca* Fletcher spends its life-cycle on a single host. It is physically impossible for it to take to a second host as the mouth parts undergo changes once the parasite clings to a host. The grubs of *Chrysopa virgestes* Banks feed both on eggs and nymphs of *Pyrilla* spp. A single grub feeds on nearly 200 eggs or an equal number of nymphs. Unfortunately some parasites retard its multiplication and reduce its value to the cane-grower. Observations were also made on the habits and behaviour of three parasites of the sugarcane hispa *Asamangulia cuspidata* Maulik. The parasite *Lestodryinus pyrrillae* Keiff has been found to hibernate in winter (4 to 5 months) and to aestivate in summer for a little over 2 months. It thus avoids extremes of temperature. This parasite is attacked by a hyper-parasite, *Lygocerus rufipes* (Thoms.)

Biological control of pests on the field scale was attempted by mass liberations of *Trichogramma minutum* Riley against the stem-borer (*Argyria sticticrasis* Hmps.) and were conducted in the Betiah Estate farms near Sagauli, North Bihar. Statistical analysis of the results as given below shows that *Trichogramma* did check the progress of the aforesaid borer as well as that of the root-borer (*Emmalocera depressella* Swinh.)

Average percentage of canes attacked by the stem-borer and the root-borer at the time of harvest :—

		Experimental	Control
		plot	plot
Lalseriah	{ Total <i>Argyria sticticrasis</i> Hmps. attack .	10.2 ± 0.40	29.4 ± 0.96
	{ Total <i>Emmalocera depressella</i> Swinh. attack .	21.2 ± 0.86	43.2 ± 1.12
Madhopore	{ Total <i>Argyria sticticrasis</i> Hmps. attack .	12.2 ± 0.91	14.7 ± 0.64
	{ Total <i>Emmalocera depressella</i> Swinh. attack .	9.2 ± 0.68	31.7 ± 1.27

Diseases.—Work was continued on the selection of varieties of wheat resistant to loose smut caused by *Ustilago Tritici* (Pers.) Jens. and flag smut caused by *Urocystis Tritici* Keorn. Out of the varieties tested against the former (36 in all), twenty took no infection and the others were infected in varying degrees. Of 70 varieties tested for resistance to flag smut, 29 took no infection. Those resistant in previous years retained their resistance.

A foot-and root-rot disease of wheat new to India was found to be causing considerable damage in the neighbourhood of Pusa, Bihar. The symptoms were reminiscent of "take-all" disease, but the fungus isolated has so far produced no perithecia.

A severe epidemic of red-rot of sugarcane caused by *Colletotrichum falcatum* Went, in the United Provinces and Bihar, gave a particularly

good opportunity to study the disease. A number of cultures were isolated from diseased canes secured from various districts. It was found that severe infection of healthy setts occurred when planted in soil contaminated with debris from infected plants. Experiments were started to determine the sources of infection and the various points at which infection may take place and were under study to find whether they represent different physiologic forms. The cane crop grown from setts obtained from plots rogued over a period of two years had only about one fortieth of the original amount of infection.

Experiments on the survival of the fungus *Fusarium orthoceras* App. et Wr. var. *pisi* Padwick which causes wilt of gram (*Cicer arietinum*) showed that the amount of fungus or its activity in the soil is greatly reduced during the period from May to October, but not entirely eliminated, under Delhi conditions. The fungus survived well in the roots of infected plants. Application of farmyard manure seemed to hasten its disappearance. Tests for varietal resistance were continued and confirmed results obtained in the previous year, I. P. Types 9, 28, and 52 being highly susceptible and I. P. 22, 63, 69 and 83 being resistant. Twenty-five varieties tested for resistance to foot-rot caused by a pycnidial fungus all took infection.

Some success was met with in attempts to bring about leaf-curl of tobacco by feeding white-flies (*Bemisia gossypiperda*) on juice extracted from leaf-curl infected plants and then transferring them to healthy plants.

Investigations have been started to determine the cause of potato tuber spoilage in storage. Out of 486 isolates from rotten tubers received from Simla periodically, 442 were species of *Fusarium*. Sixteen isolates tested for their pathogenicity on tubers of the varieties "Darjeeling", "Gola", "Great Scott", and "Phulwa" all caused rotting in varying degrees.

A large amount of taxonomic work was done. In the Sub-section Orthocera of the genus *Fusarium*, *F. conglutinans* Wr. is a synonym of *F. orthoceras* App. et Wr. The gram wilt fungus is regarded as a variety of *F. orthoceras*. The fungi which cause wilt of pigeon-pea and sann-hemp are considered to be morphologically distinct from *F. vasinfectum* Atk., and the original name *F. udum* Butler is reinstated. The so-called "foot-rot" organism of pigeon-pea, *F. lateritium* Nees var. *uncinatum* Wr. is considered identical with *F. udum*.

In the genus *Phytophthora*, it is interesting to note that a species which causes a form of "late-blight" of potatoes in Simla is distinct from *P. infestans* de By. and appears to be *P. parasitica* Dast. It attacks tomato as well as potato and can cause severe damage. Other *Phytophthoras* under study include isolates from brinjals, oranges and apples.

Examination was made of 73 collections of smut of sugarcane (*Saccharum officinarum* and *S. Barberi*). It was concluded that the culmicolous smut of sugarcane consists of one species, *Ustilago scitaminea*, with two varieties, var. *Sacchri-Barberi*, with smaller spores, and var. *Sacchari-officinarum*, with longer spores than the fundamental species.

III. GENERAL ADMINISTRATION

Staff.—A list of the staff together with such changes as took place in various Sections is given in Appendix I (pp. 120-121).

Schemes of Research financed by the Imperial Council of Agricultural Research.—All the schemes referred to in the last year's report continued to be in operation with the exception of the one for Research on Chemistry of Sugarcane which came to a close in May 1940. A portion of the staff of this Scheme has however been retained for another year in order to enable the work on hand to be completed. The term of the Scheme for potato-breeding in Northern India expired in March 1940, and the Council has sanctioned its extension for a further period of five years. A new Scheme having for its object the development of research on the lines suggested by Sir John Russell came into effect from 1st June 1940.

Besides the above, the work of testing Indian barleys for malting purposes was carried out at the Institute for the United Provinces Department of Agriculture with the assistance of special staff paid from the Council's grant.

Training.—Of the 82 candidates who applied for admission to the post-graduate courses beginning in October 1939, sixteen were selected for admission, three in Botany, three in Agricultural Chemistry, two in Entomology, three in Mycology, three in Agriculture and two in Sugarcane Breeding. Of these, one in Agricultural Chemistry and one in Mycology left the course a few days after admission. Ten students completed the course during the year and were awarded The Institute Diploma; four in Botany, two in Agricultural Chemistry, two in Entomology and two in Mycology. The one-year course in Farm Organisation and General Farm Engineering was completed by five students. Besides the regular courses, facilities were given to sixteen students for short training in special subjects and to ten honorary research workers for carrying out a definite piece of work. Students from the Imperial Dairy Institute, Bangalore, were also afforded facilities to study the methods of cattle-breeding and mixed farming at the Institute and its Sub-station at Karnal.

For further details attention is invited to Appendix II (pp. 122—124).

Library.—The total number of publications received in the Library by purchase as well as by way of exchange amounted to 2,665. Over 3,370 books were issued on loan, of which 475 were sent out to workers in Provinces.

IV. ACCOUNTS

The total expenditure of the Institute and its Sub-stations at Karnal and Coimbatore during the financial year ended March 1940 amounted to Rs. 7,19,549.

Name of Establishment	Expenditure Rs.
General expenditure of the Institute, including the office of the Director, Irrigation, Power supply, Gas Plant and the Estate Establishment	2,00,427
Agriculture Section	1,12,527
Botany Section	48,816
Chemistry Section	78,054
Entomology Section	64,806
Mycology Section	41,707
Locust Warning Organisation	27,729
Agricultural Sub-station, Karnal	63,199*
Sugarcane Station, Coimbatore	82,285
	7,19,549

The expenditure of the various Research Schemes financed by the Imperial Council of Agricultural Research amounted to Rs. 1,37,932, as shown below, which was met from the funds provided by the Imperial Council of Agricultural Research,

	Rs.
(a) Research on Diseases of Sugarcane	21,826
(b) Research on Insect Pests of Sugarcane	32,409
(c) Research on Chemistry of Sugarcane	6,606
(d) Research on Genetics of Sugarcane	2,133
(e) Sugarcane Sub-station, Karnal	13,167
(f) Tobacco Breeding Sub-station, Guntur	19,698
(g) Potato and Wheat Breeding Sub-station, Simla	
	Rs.
Potato Breeding	10,019
Wheat Breeding	7,136
(h) Botanical Sub-station, Pusa	24,532
(i) Analysis of Cinchona Soils	406
	1,37,932

*Vide the certified income and expenditure account reproduced below.

The receipts of the Institute and its Sub-stations amounted to :—

	Rs.
Main Institute	37,995
Agricultural Sub-station, Karnal	53,487*
Sugarcane Station, Coimbatore	7,695

**Vide* the certified income and expenditure account reproduced below.

Income and expenditure account for the year ending 31st March 1940—Agricultural, Sub-station Karnal.

Income	1938-39	1939-40	Expenditure	1938-39	1939-40
1. By sale of Dairy Produce, etc.	.	12,919	1. Pay of officers and establishment	27,814	22,831
2. By sale of Farm Produce, etc.	.	22,824	2. Travelling allowances	613	198
3. By Miscellaneous Receipts	.	832	3. Feed of Dairy Cattle, etc.	3,199	3,165
Deficiency	.	39,053	4. Production of grain and fodder, etc.	18,885	21,188
Total	.	75,628	5. Ice, Salt, Acid, etc.	11	32
			6. Medical Stores	640	689
			7. Workshop	1,697	1,852
			8. Fuel, light, water, etc.	2,967	2,845
			9. Service Stamps, etc.	360	306
			10. Freight on stores	163	183
			11. Miscellaneous contingencies	1,699	1,491
			12. Capital expenditure	8,677	2,034
			13. Repairs to plant and Machinery	1,800	2,768
			14. Petty construction and repairs.	7,103	3,616
				75,628	63,198

REPORT OF THE IMPERIAL AGRICULTURIST (ARJAN SINGH, ASSISTANT AGRICULTURIST)

Introduction

Before dealing with the report, it will not be out of place to put in a few lines here in appreciation of Mr. Wynne Sayer, late Imperial Agriculturist, who held charge of this Section for the last ten years. Mr. Sayer proceeded on leave on 5th May 1939 and subsequently extended his leave preparatory to retirement. The design and lay-out of the Farm, including the arable area and buildings at the new site of the Institute in Delhi, which are so well planned, were made by him. His extensive work on sugarcane is well known to all who are engaged in this line of research. Mr. Sayer's achievements in the field of cattle breeding are unique in India. He is a gifted cattle-breeder and organizer. The outstanding records of the Pusa pedigree Sahiwal herd have been made possible through his farsighted policy. His original works on early maturity, four-time milking and pre-milking in the Sahiwal herd have been brought to a point of practical utility of high economic importance, as is evident from the great strides in the performances made by the early maturity cattle from heifer to adult cows and down to the third generation in a short period of eight years.

The lay-out and levelling of the farm at Delhi and the construction of a drainage system at the Agricultural Sub-station, Karnal, were completed, and the major policies for working of the two farms have been laid down as follows :—

- (1) The Delhi Farm will be worked by bullock power only, and most of the experimental work is to be concentrated here. The arable area will be divided into two units : one for raising grain and fodder for cattle, and the other for experimental work. In times of limited supply of irrigation water, grain and fodder crops and long-term experiments (including those in the Botanical Section) will have priority, as they cannot be interrupted without seriously affecting the ultimate results.
- (2) The Karnal Sub-station will be a mechanical power farming unit for large-scale cultural and mixed farming experiments, and multiplication of seeds of improved varieties, and as such the area will be divided into two distinct units, *viz.*, (i) a mixed farming area in which grain and fodder crops will be grown for cattle and seeds multiplied, and (ii) an experimental area.

1. Agricultural Section, New Delhi

I. AREA UNDER CULTIVATION

The area of 400·89 acres has been divided as follows :—

Fields					Acres	
Main Block	.	.	.	.	240·00	} For raising grain and fodder crops for cattle.
Top Block	.	.	.	.	50·56	
Paddock No. 1	.	.	.	.	16·72	
Total					307·28	
Shadipur Block	.	.	.	.	22·43	} For experimental work.
Middle Block	.	.	.	.	43·89	
Total					66·32	
Paddock No. 2	.	.	.	.	3·84	For grazing.
Sewage Block	.	.	.	.	23·45	For disposal of effluent of the activated sludge plant ; fodder crops and grasses to be raised.

II. SEASON AND CROPS

1. SEASON

The total rainfall during the year from June 1939 to May 1940 amounted to 20·20 inches, as compared with 10·38 inches in the previous year. The monthly records were : June 1939—5·46 inches ; July—3·06 inches ; August—3·89 inches ; September—3·88 inches ; January 1940—1·62 inches ; February—1·50 inches and March—0·79 inch.

The monsoon broke early with 1·12 inches of rainfall on 11th June, which enabled to complete the *kharif* sowing in proper time. 3·88 inches of rainfall in the middle of September was much helpful in sowing *rabi* crops, but the total absence of rains in October, November and December badly affected the gram crop which could not be irrigated. Later on, the winter rains in January and February proved very beneficial for all *rabi* crops, including gram which was saved from total failure.

2. CROP YIELDS

The following is the crop yield statement for the year under report.

Statement of crop yields during 1939-40

Crop and variety	Area in acres	Total	Yield in maunds*		Remarks (1939-40)
			Average per acre	Average yield per acre 1938-39 Mds.	
Jowar—green fodder . . .	13·50	3905·25	289·28	272·49	Manured with F. Y. M.
Ditto . . .	25·40	3996·69	157·35	..	Not manured.
Jowar and guar fodder . . .	30·00	8743·18	291·44	..	Manured with F. Y. M.
Ditto . . .	10·76	3334·33	309·88	..	Not manured.
Bajra and cowpeas fodder . . .	31·03	6658·47	214·58	..	
Maize No. 2 fodder . . .	0·75	217·55	290·07	..	
Maize No. 1—Corn . . .	0·50	3·90	7·80	11·08	
" No. 2 " . . .	2·80	36·47	13·03	7·55	
" No. 3 " . . .	0·50	5·43	10·86	6·68	
Soybean—Coorg . . .	1·50	5·38	3·59	2·50	
" Black . . .	1·50	4·25	2·83	3·67	
" Yellow . . .	1·50	6·00	4·00	3·94	
" Chocolate . . .	1·50	4·93	3·29	3·03	
Guar . . .	6·00	73·88	12·31	..	
Bajra and cowpeas . . .	1·00	7·70	7·70	..	
Cowpeas K. 596 . . .	3·00	19·10	6·37	..	
" K. 789 . . .	3·00	24·33	8·11	..	
" K. 397 . . .	3·00	21·63	7·21	..	
Groundnut . . .	0·50	0·35	0·70	4·26	Badly damaged by white ants.
Cotton 4 F. . .	2·00	13·89	6·95	6·52	
" 289 F . . .	0·51	1·56	3·06	4·64	
" M. 60 A/2 . . .	0·30	1·23	4·10	5·20	
Oats I. P. 1 . . .	96·06	2904·40	30·24	28·78	
" I. P. 2 . . .	5·00	164·50	32·90	..	
" Hybs. 1 & 3 . . .	5·00	137·00	27·40	28·37	
Wheat I. P. 165 . . .	10·50	249·22	23·74	18·89	
Barley I. P. 13 . . .	12·34	409·05	33·15	43·02	
Gram I. P. 17 . . .	25·00	100·73	4·03	..	Unirrigated.
" I. P. 25 . . .	49·00	393·56	8·03	..	Do.
" I. P. 25 . . .	1·90	29·51	15·53	10·57	Irrigated.
" I. P. 53 . . .	12·04	104·99	8·72	..	Unirrigated.
" I. P. 58 . . .	23·48	177·54	7·56	..	Do.
Peas I. P. 29 . . .	4·63	85·08	18·38	17·05	
Berseem—green fodder . . .	33·75	16,380·03	485·34	397·04	(3 to 5 cuttings plus 8 mds. seed)
Lucerne—green fodder . . .	0·75	282·95	377·27	288·00	11 cuttings.
Sugarcane . . .	3·25	1,483·73	456·53	259·25	

*1 maund=82·3 lb.

It will be seen from the above statement that considerable improvement in crop yields has again been effected. The yield of oats in plot Nos. 1, 2 and 3 in the main block is of special interest as compared with the previous years' figures.

Yields of oats per acre in maunds

Plot No.	1936-37	1938-39	1939-40
1	18·78	27·34	31·67
2	23·94	29·07	35·00
3	20·30	27·79	32·15

Grain and fodder unit.—The area devoted for this purpose was worked under rotation Nos. 1, 2 and 3 mentioned in the last year's report. The production of grain and fodder from this area in *kharif* 1939 and *rabi* 1939-40, and that consumed by cattle in 12 months from 1st April 1939 to 31st March 1940 are given below.

Number of cattle maintained			Grain consumed			Total produce	Difference
B. H.	W. C.	Total	B. H.	W. C.	Total	Mds.	Mds.
203	84	287	Mds. 2,817	Mds. 1,825	Mds. 4,642	Mds. 3,944	—698

Green fodder consumed			Total produce	Difference
B. H.	W. C.	Total	Mds.	Mds.
Mds. 26,724	Mds. 14,468	Mds. 41,192	Mds. 45,358	+4,164

Dry fodder consumed			Total produce	Difference
B. H.	W. C.	Total	Mds.	Mds.
Mds. 2,785	Mds. 2,754½	Mds. 5,540½	Mds. 5,438½	—102

NOTE.—B. H. stands for breeding herd and W. C. for work cattle.

In carrying out this mixed farming programme, we are very much handicapped by the limited supply of irrigation water. Had we been able to irrigate 100 acres of gram crop once before X'mas, the grain deficit would have been more than balanced.

Dry Farming.—A block of about six acres was kept fallow during *kharif* 1939. The rain moisture was conserved by ploughing and harrowing the fields after rains—once every month—till the sowing of *rabi* crops in October. The monsoon rainfall (June to September) was 16·29 inches and that of winter was 3·91 inches.

The following crops were sown in *rabi*, the yields of which are given below :—

Crops.	Area in acres	Yield per acre Mds.
Gram I. P. 53	1.00	13.05
Kerao	1.12	7.90
Peas I. P. 29	0.53	15.56
Khesari	0.53	7.00
Barley	1.12	20.00
Oats I. P. 1	1.06	15.23
*Wheat I. P. 120	1.00	..

*Wheat was damaged by white ants.

3. FODDER CROP INVESTIGATIONS

Jowar.—Trials with eight varieties of *jowar* were carried out, and the results are given under "Field Experiments".

Bajra.—This was sown for the first time for green fodder and silage. It gave high yield of green fodder, and one silo pit was filled in with 3,000 maunds of green *bajra*. Both green fodder and silage were not relished by the Sahiwal herd and caused irritation in the stomach, but they were taken readily by work bullocks without any ill effects.

Berseem.—The total area under berseem fodder was 33.75 acres. We are now entirely self-supporting as regards seed requirements both at Karnal and Delhi and also are in a position to sell a limited quantity of seed.

Alternative rabi fodders.—Experiments with berseem, *methra*, *senji*, *kerao*, *khesari* and barley were continued. The details will be found under "Field Experiments".

Lucerne.—The lucerne crop sown in the previous year continued to grow during the year under report, and it was possible to take one cut every month, except August. The total yield of green fodder was 377 maunds per acre. A small patch was left for seed from which a small quantity of good seed was harvested.

Grasses.—The following grasses were under trial :—

1. *Anjan* (*Pennisetum cenchroides*)
2. *Palwal-jerga* (*Andropogon ischaemum*)
3. *Dub* (*Cynodon dactylon*)
4. Guinea-grass
5. Elephant-grass
6. Rhodes-grass

7. *Bara-jerga* (*Andropogon annulatus*)
8. *Goroya* (*A. monticola*)
9. *Chhoti-jerga* (*A. pertusus*)
10. *Murjhain* (*A. foveolatus*)
11. Sudan-grass.

The first three did not grow well as cultivated grasses and were smothered by weeds in the second year.

Guinea-grass.—This grass remained stunted in growth during winter, but gave three cuttings in summer. It was much relished by work cattle.

Elephant-grass.—It is a bulky fodder crop liked by work cattle. It remained dormant in winter. 1,277 maunds of green grass was cut from a plot of 0·89 acre during the year.

Rhodes-grass.—This grows throughout the year. It was cut nine times, but the yield was rather low. It gives soft succulent fodder which is relished by cattle.

Andropogons.—These grasses were sown from seed for the first time during the cold weather and were practically without any growth in the beginning, but they are now growing well and look like pasture grasses. Further observations are being taken.

Sudan-grass.—This is an annual grass. In the first cut it gave 264 maunds of green fodder per acre. The second crop was kept for seed. Milch cows refused to take it, but it was suitable for work cattle.

4. SUGARCANE VARIETAL WORK

The importation of new varieties of sugarcane from Coimbatore and their testing and multiplication were continued. Unlike Pusa, the multiplication of planting material takes a long time at Delhi, as short planting method is not successful here. During the first year of importation, very little material is available as the canes have to struggle hard under new environment. It is only after three years that sufficient planting material can be had for a large-scale trial.

During the year under review, the following varieties of sugarcane, besides the standard ones, were under trial :—

1. Imported in 1930—Co. 336.
2. Imported in 1931—Co. 344, Co. 347, and Co. 348.
3. Imported in 1932—Co. 381, Co. 382, Co. 384, Co. 386, and Co. 391.
4. Imported in 1933—Co. 336, Co. 368, Co. 370, Co. 371, Co. 474.
Co. 377, Co. 378, Co. 413, and Co. 419.

5. Imported in 1934—Co. 421, Co. 423, Co. 424, Co. 425, Co. 426, Co. 427, Co. 428, Co. 429, Co. 430, Co. 431, Co. 500, Co. 501, Co. 502, Co. 503, Co. 504, Co. 505, Co. 506, Co. 507, Co. 508, Co. 509, Co. 510, Co. 511, Co. 512, Co. 513, Co. 514, and Co. 516.
6. Imported in 1935—Co. 432, Co. 433, and Co. 434.
7. Imported in 1937—Co. 441, Co. 442, Co. 443, Co. 444 and Co. 445.
8. Imported in 1938—Co. 446, Co. 447, Co. 448, Co. 449, Co. 450, Co. 451, Co. 452, Co. 453, Co. 454, Co. 455, Co. 456, Co. 534, Co. 535, Co. 536, Co. 537, Co. 538, Co. 539, Co. 540, Co. 541, Co. 452, Co. 543, Co. 544, and Co. 545.
9. Imported in 1939—Co. 457, Co. 458, Co. 459, Co. 546, Co. 547, Co. 548, and Co. 549.

Co. 444 and Co. 537 showed a very good stand, and although they are tall growing varieties, they did not lodge.

The following 15 varieties were rejected owing to their stunted growth and other undesirable characters :—

Co. 417, Co. 449, Co. 500, Co. 501, Co. 502, Co. 503, Co. 504, Co. 505, Co. 506, Co. 507, Co. 508, Co. 509, Co. 510, Co. 514, and Co. 516.

The following varieties appeared to be heavy tonnage yielders combined with high sucrose content.

Varieties	Average weight of cane		Sucrose per cent in juice		
	December 1939	January 1940	December 1939	January 1940	March 1940
Co. 428	2·56	1·75	16·37	17·82	..
Co. 457	2·33	1·55	15·62	16·68	15·49
Co. 421	2·04	1·41	15·08	16·58	17·85
Co. 444	2·03	1·81	10·74	12·65	18·53
Co. 443	1·70	2·00	9·93	16·27	14·91
Co. 540	1·69	1·35	17·55	17·58	..
Co. 537	1·53	1·06	12·52	16·04	17·46
Co. 423	1·69	1·62	9·62	15·89	..
Co. 446	1·56	0·59	18·78	18·93	..
Co. 450	1·58	2·50	15·07	71·23	17·79
Co. 454	1·50	1·50	13·88	15·39	18·46
Co. 535	1·56	1·12	15·76	19·14	20·43
Co. 419	1·93	1·75	15·54	17·40	..

5. MANURING

Collection and storage of farmyard manure were continued. Out of the manure produced during the year, 17,107 maunds was applied to fields on the farm, particularly in the grain and fodder block. 189 maunds was supplied to other Sections of the Institute.

Investigations on the storage of farmyard manure with special reference to fly breeding have been taken up in collaboration with the Medical Officer of Health, New Delhi, the Imperial Entomologist and the Imperial Agricultural Chemist.

6. CROPS GROWN FOR OTHER SECTIONS OF THE INSTITUTE

Like last year, different crops were grown in small plots for the Imperial Entomologist in *kharif* and *rabi* for the study of insect pests.

A field experiment was conducted for the Imperial Entomologist for the study of the effect of pink and spotted boll-worms on cotton.

Eight varieties of sugarcane were grown for the Biological Control Research Officer for the study of pests during the year under report.

A field experiment was conducted for the Imperial Agricultural Chemist for the study of nitrogen fixation by the maize plant.

A field experiment was carried out for the Imperial Mycologist for the study of gram wilt.

Fifty-seven varieties of healthy and eighteen varieties of mosaic affected sugarcane, collected from different localities, were grown for the Plant Pathologist for the study of mosaic disease.

7. SEED SUPPLY

The quantities of seeds distributed from Delhi are shown below :—

Crops	Quantity Lb.
Arhar (<i>Cajanus indicus</i>)	6·17
Barley	123·42
Berseem	229·36
Cowpeas	247·35
Gram	164·56
Khesari (<i>Lathyrus sativus</i>)	10·29
Kerai (<i>Pisum arvense</i>)	10·29
Meth (<i>Phaseolus aconitifolius</i>)	4·63
Maize	109·02
Oats	1,213·63
Soybean	197·99
Sudan-grass (seed)	67·37
Sugarcane (setts)	117,390·93
Wheat	368·20

III. FIELD EXPERIMENTS

1. BERSEEM EXPERIMENTS

These experiments, started in 1937-38 and carried out on the same lines as before, were concluded during the year under report with the following results.

(i) *Seed production experiment, Top Block No. 1.*—Like previous years, the experiment was laid down in randomized blocks with six replications.

Treatments	Mean yield of seed per plot in oz. (.022 acre)	Percentage on general mean	' z ' test	Critical difference
Berseem seed obtained after—				
A.—1st cutting (December)	21.33	144.14	Significant	4.535
B.—2nd cutting (January)	20.00	135.14	at 1 per	(P = .05)
C.—3rd cutting (February)	12.00	81.08	cent level.	6.186
D.—4th cutting (March)	5.33	36.04		(P = .01)
E.—5th cutting (April)	15.33	103.60		

Conclusions :—A = B > C, D & E ; C = E > D.

The results of the duplicate experiment carried out at Karnal (Main Block, Plot No. 6) are given below :—

Treatments	Mean yield of seed per plot in oz. (.022 acre)	Percentage on general mean	' z ' test	Critical difference
Berseem seed obtained after—				
A.—1st cutting (November)	46.67	100.36	Significant	18.573
B.—2nd cutting (January)	59.50	127.96	at 1 per	(P = .05)
C.—3rd cutting (February)	86.00	184.95	cent level.	25.331
D.—4th cutting (March)	21.83	46.95		(P = .01)
E.—5th cutting (April)	18.50	39.78		

Conclusions :—C > B = A > D = E.

Comparing the results of the three years, it is evident that maximum quantity of seed is obtained normally after the third cut, unless there are other factors, like early monsoon, scarcity of irrigation water, which tend to give abnormal results.

(ii) *Optimum interval for irrigation, Top Block No. 1.*—As before, the experiment was conducted in six randomized blocks.

Treatments	Mean yield of green fodder per plot in lb. (.022 acre)	Percentage on general mean	'z' test	Critical difference
Irrigation at—				
A.—8 days' interval . . .	1539.8	112.87	Significant	125.92
B.—10 „ „ . . .	1471.7	107.87	at 1 per	(P = .05)
C.—12 „ „ . . .	1460.0	107.01	cent level.	171.74
D.—16 „ „ . . .	1219.3	89.37		(P = .01)
E.—20 „ „ . . .	1130.7	82.88		

Conclusions :—A = B = C > D = E.

The three years' results show that there are no significant differences among irrigation intervals of 8, 10 and 12 days.

2. VARIETAL YIELD TRIALS

(i) *Jowar for fodder and grain, Main Block, Plot No. 7.*—Eight varieties of jowar were tested for green fodder and grain separately, each in six randomized blocks. The results are tabulated below.

Varieties	Mean yield per plot in lb. (.0193 acre)		Percentage on general mean	
	Fodder	Grain	Fodder	Grain
A.—Local (Delhi) . . .	592.8	7.38	110.44	94.71
B.—Sirsa 20 . . .	490.6	12.83	91.41	164.81
C.—Sirsa 21 . . .	555.3	2.38	103.47	30.50
D.—Sirsa 100 . . .	636.0	2.33	118.50	29.97
E.—Cawnpore 8 B . . .	581.3	13.33	108.30	171.23
F.—Cawnpore 5 . . .	568.1	12.96	105.85	166.42
G.—Honey sorghum (Sind) . . .	499.6	3.92	93.08	50.29
H.—Red Turi (Sind) . . .	582.7	7.17	108.57	92.04
'z' test . . .	Sig. at 1 per cent level.	Sig. at 1 per cent level.		
Critical differences :—				
(P = .05) . . .	58.35	3.096		
(P = .01) . . .	78.30	4.154		

Conclusions (i) Fodder :—A = C = E = F = H > B = G ; D > B, C, F & G.

(ii) Grain :—B = E = F > A, C, D, G & H ; A = H > C = D = G.

Cawnpore 8B and Cawnpore 5 are very late varieties for fodder and require one extra irrigation; Sirsa types and the local variety are medium, while Honey Sorghum and Red Turi are early varieties. Cawnpore varieties being late, it was not possible to grow gram after them as no moisture was left in the field.

(ii) *Wheat, Middle Block, A3.*—The experiment was concluded this year after three years' trial. It was carried out on the same lines as reported last year. The results are summarised below:—

Varieties	Mean yield of grain per plot in lb. (·017 acre)	Percentage on general mean	'z' test	Critical difference
I. P. 4	48·75	111·01	Significant	8·379
„ 12	48·38	110·15	at 1 per	(P = ·05)
„ 80·5	46·21	105·22	cent level;	11·159
„ 111	46·75	106·45		(P = ·01)
„ 114	41·92	95·45		
„ 120	36·33	82·73		
„ 125	47·17	107·40		
„ 165	46·88	106·74		
„ 52	34·00	77·42		
8 A	37·67	85·77		
C. 518	50·83	115·75		
C. 591	42·13	95·92		

Conclusions:—C. 518 > I. P. 52 = I. P. 120 = 8 A = I. P. 114 = C. 591; C. 518 = I. P. 4 = I. P. 12 = I. P. 80·5 = I. P. 111 = I. P. 125 = I. P. 165 > I. P. 52 = I. P. 120 = 8 A.

Considering the three years' results, it is found that C. 518 has given the highest yield; but it is a late variety as compared with I. P. wheats. The other high yielding varieties are I. P. 4, I. P. 12, and I. P. 165 and their yields are not significantly different from that of C. 518.

(iii) *Gram, Main Block, Plot No. 8.*—This experiment was also concluded during the year under report after three years' trial. The results are given

below. As in previous years, the experiment was laid down in six randomized blocks.

Varieties	Mean yield of seed per plot in lb (.0167 acre)	Percentage on general mean	'z' test	Critical difference
A.—I. P. 17	9.46	113.15	Significant	4.445
B.— „ 25	9.79	117.13	at 1 per	(P = .05)
C.— „ 28	4.79	57.32	cent level.	5.965
D.— „ 58	9.42	112.65		(P = .01)
E.—P. F. 3	9.50	113.65		
F.— „ 6	7.88	94.21		
G.— „ 11	13.79	164.99		
H.— „ 17	2.25	26.92		

Conclusions :—A, B, D, E & G > H = C; F > H; G > A, B, C, D, E, F & H; A = B = D = E = F.

All the varieties were affected, by wilt, I. P. 28, P. F. 6 and P. F. 17 suffered most. The three years' results show that I. P. 58, I. P. 25, P. F. 3, P. F. 11 and I. P. 17 are high yielding varieties. At Pusa, P. F. 11 gave the best yield and this was followed by I. P. 58.

(iv) *Sugarcane for tonnage yield, Middle Block, A 5*.—Twelve varieties were tested in randomized blocks with six replications. The results are given below :—

Varieties	Sucrose per cent in juice		Tonnage yield per plot in lb (.014 acre)	Percentage on general mean	'z' test	Critical difference
	December	January				
Co. 312	9.42	11.14	971.9	142.43	Signifi-	116.10
Co. 313	14.15	13.53	625.0	91.59	cant at	(P = .05)
Co. 331	9.71	9.65	982.6	143.98	1 per	154.62
Co. 381	17.64	18.96	308.6	45.21	cent level.	(P = .01)
Co. 511	14.16	14.79	392.5	57.52		
Co. 244	11.28	13.74	689.4	101.03		
Co. 421	15.08	16.58	627.4	91.94		
Co. 512	15.00	15.68	842.7	123.49		
Co. 508	18.18	17.28	612.0	89.68		
Co. 432	14.12	15.30	608.5	89.17		
Co. 213	10.03	12.98	661.7	96.96		
Co. 285	12.44	14.89	866.7	127.00		

Conclusions :—Co. 331 = Co. 312 = Co. 285 = Co. 512 > Co. 244 = Co. 213 = Co. 421 = Co. 313 = Co. 508 = Co. 432 > Co. 511 = Co. 381.

(v) *Cold weather fodder crops, Middle Block, A 1*.—The area which was under this experiment during 1938-39 was put under maize No. 2 in *khari* 1939 without any treatment to note the residual effect of the various *rabi* fodder crops on the yield of green maize. The yields are given below :—

Treatments	Mean yield of green maize per plot in lb (.0125 acre)	Percentage on general mean	'z' test	Critical difference
A.—Berseem	231.0	76.54	Significant	62.42
B.— <i>Senji</i>	343.2	113.71	at 5 per	(P = .05)
C.— <i>Methra</i>	335.0	111.00	cent level.	85.13
D.— <i>Kerao</i>	317.0	105.04		(P = .01)
E.— <i>Khesari</i>	297.7	98.63		
F.—Barley & <i>Kerao</i> . .	287.0	95.10		

Conclusions :—B = C = D = E = F > A, except F.

All the plots, except those under 'A', remained fallow for 3 to 4 months before maize was sown, while from 'A' the last cutting of berseem was taken at the end of May and maize was sown in mid-June.

In order to investigate whether the poor yield of maize fodder after berseem is due to the short fallow, a fresh treatment 'B' has been included in the experiment from which berseem fodder was cut till March and then ploughed in to allow a long fallow like the other plots. It was laid out in randomized blocks with six replications. The results of the yield trial with *rabi* fodder crops are given below. The yields of green maize will be given in the next year's report.

Fodder crops	No. of cut- tings	Mean yield of green fodder per plot in lb (.012 acre)	Percentage on general mean	'z' test	Critical difference
A.—Berseem (cut up to May).	6	507.3	165.80	Significant	104.76
B.—Berseem (cut up to March)	4	389.9	127.43	at 1 per	(P = .05)
C.— <i>Methra</i>	2	256.9	83.95	cent level.	141.08
D.— <i>Kerao</i>	1	277.9	90.81		(P = .01)
E.— <i>Senji</i>	2	199.2	65.09		
F.— <i>Khesari</i>	1	280.2	91.57		
G.—Barley & <i>Kerao</i> . .	1	230.6	75.35		

Conclusions :—A > B > F = D = C = G = E.

A record of the number of irrigations given to the various crops and also of the approximate quantity of water used at each irrigation was maintained. The figures are tabulated below :—

Crops	No. of irrigations given	Total quantity of irrigation water used (·0723 acre)	Total quantity of irrigation water used per acre	Average quantity of irrigation water used per acre for one irrigation	Quantity of irrigation water used per 100 lb of green fodder
		Galls.	Tons.	Tons.	Galls.
Berseem (cut up to May) .	18	76,479	4,721·4	262·3	2,512·5
Berseem (cut up to March.)	13	61,013	3,766·6	289·8	2,608·0
Methra	10	44,289	2,734·2	273·4	2,873·6
Kerao	4	16,021	989·1	247·3	960·9
Senji	11	45,362	2,800·4	254·6	3,796·0
Khesari	5	21,423	1,322·5	264·5	1,274·2
Barley & Kerao	4	17,982	1,110·1	277·5	1,299·7

3. MISCELLANEOUS EXPERIMENTS

(i) *Manurial experiment, Middle Block, A2.*—A new experiment was laid down with twelve treatments in randomized blocks with six replications. All the manures were applied before the *kharif* sowing. Maize was sown in *kharif* and barley was grown in *rabi* to see the residual effect of the manures.

Treatments per acre	Maize No. 2		Barley I. P. 13.	
	Mean yield of grain per plot in lb (·0164 acre)	Percentage on control	Mean yield of grain per plot in lb (·0164 acre)	Percentage on control
A.—No manure (control)	18·26	100·00	31·88	100·00
B.—F. Y. M. at 40 lb. N. . . .	18·51	101·42	29·04	91·11
C.—Activated sludge at 40 lb. N. .	21·00	115·02	31·00	97·25
D.—Rape cake at 40 lb. N. . . .	21·26	116·43	28·58	89·67
E.—F. Y. M. at 40 lb. N. + 50 lb. P ₂ O ₅ as super. + 50 lb. K ₂ O as pot. sulph.	18·43	100·95	35·79	112·29
F.—Activated sludge at 40 lb. N + P ₂ O ₅ & K ₂ O as in 'E'.	20·23	110·81	34·04	106·80
G.—Rape cake at 40 lb. N + P ₂ O ₅ & K ₂ O as in 'E'.	20·57	112·69	26·88	84·31
H.—Compost at 40 lb. N. . . .	20·74	113·62	28·00	87·84

Treatments per acre	Maize No. 2		Barley I. P. 13	
	Mean yield of grain per plot in lb (.0164 acre)	Percentage on control	Mean yield of grain per plot in lb (.0164 acre)	Percentage on control
I.—Compost at 20 lb. N + 20 lb. N as amm. sulph.	21.26	116.43	32.58	102.22
J.—F. Y. M. at 20 lb. N + 20 lb. N as in 'I'.	24.08	131.93	33.67	105.62
K.—F. Y. M. at 120 lb. N . . .	23.57	129.12	37.00	116.08
L.—Complete artificials :				
40 lb. N as amm. sulph. + 50 lb. P ₂ O ₅ as super. + 50 lb. K ₂ O as pot sulph.	21.94	120.20	32.71	102.61
'z' test.	Not significant.		Not significant.	
Critical difference :				
P = .05	3.86	..	8.13	..
P = .01	5.15	..	10.85	..

(ii) *Spacing experiment with gram I. P. 17, Main Block, Plot No. 7.—*

This was conducted in six randomized blocks with the following results :—

Spacing	Mean yield of grain per plot in lb (.0207 acre)	Percentage on general mean	'z' test	Critical difference
9 inches.	23.83	105.34	Not	2.880
12 inches.	22.38	98.90	significant.	(P = .05)
15 inches.	21.54	95.21		
18 inches.	22.75	100.55		

Although there is no significant difference in yields between 9 inches and 18 inches spacings, there is 50 per cent saving in the quantity of seed sown at 18 inches.

(iii) *Determination of the best time for sowing gram, Middle block, A6.—*
The experiment was carried out on the same lines as reported last year.

Like last year, the late sown plots yielded more than the early sown plots. Gram I. P. 25 was employed for the test.

Treatments	Mean yield of seed per plot in lb (.0174 acre)	Percentage on general mean.	'z' test	Critical difference
Plots sown on—				
A.—23rd September 1939	22.58	87.70	Not	4.130
B.—30th September 1939	25.58	99.35	significant.	(P = .05)
C.—7th October 1939	25.83	100.32		
D.—14th October 1939	25.33	98.38		
E.—21st October 1939	28.75	111.65		
F.—28th October 1939	26.42	102.59		

(iv) *Effect of ploughing with victory plough (inversion) and desi plough (non-inversion) on the yield of barley I. P. 13, Main Block, Plot No. 7.*—Twenty long and narrow plots were laid down in the order of A B B A A B, 'A' under victory plough and 'B' under *desi* plough. The results of ploughing, as judged from the yield of barley are given below :-

Mean difference in favour of victory plough = 4.45 lb.

Critical difference :

(P = .05) 4.03

(P = .01) 5.51

The difference is significant at the 5 per cent level.

(v) *Village plot experiment, Shadipur A, B & C.*—This experiment was started in 1938-39 in duplicate on an area of $7\frac{1}{2}$ acres each, based on an average small holding. The object of the experiment is to investigate how far a man on a holding of this size with irrigation facilities would be able to support his family consisting of himself, his wife and one or two children and his live-stock consisting of 2 bullocks, one milch animal with one or two young stock and at the same time maintain or increase the fertility of his holding by the application of farmyard manure produced by his live-stock and by proper rotation of crops. The cropping scheme and rotations are given below. The details of production with cost are being maintained. The experiment is now in its third year.

Cropping Scheme

<i>Kharif</i>				Area	<i>Rabi</i>				Area
				Acres					Acres
Maize				0.5	Wheat				3.5
Sugarcane				0.5	Barley				0.5
Jowar				1.5	Peas				0.5
Cotton				1.0	Gram				1.5
Total				3.5	Total				6

*Rotations**4-year rotation plot Nos. 1, 2, 3 and 4.*

<i>Khariif</i>					<i>Rabi</i>					Area Acres
Maize	.	.	.	.	Peas	.	.	.	.	0.5
Cotton	.	.	.	.	Cotton	.	.	.	.	0.5
Sugarcane	.	.	.	.	Sugarcane	.	.	.	.	0.5
Fallow	.	.	.	.	Wheat	.	.	.	.	0.5

3-year rotation plot Nos. 7, 8 and 9.

<i>Jowar</i>	.	.	.	.	Gram	.	.	.	.	1.5
Fallow	.	.	.	.	Wheat	.	.	.	.	1.5
Green manure	.	.	.	.	Wheat	.	.	.	.	1.5

2-year rotation plot Nos. 5 and 6.

Cotton	.	.	.	.	Cotton	.	.	.	.	0.5
Fallow	.	.	.	.	Barley	.	.	.	.	0.5

IV. MACHINERY AND IMPLEMENTS

Most of the machinery and implements were transferred to the Agricultural Sub-station, Karnal, as the work on power farming is to be carried out there.

Forty-one country ploughs collected from the different provinces of India were labelled, weighed and photographed. A suitable technique is being designed to measure the D. B. P. of these ploughs by means of a recording traction dynamometer.

A four-wheel vehicle with pneumatic equipment and provided with a special articulated device for the front axle was received from Messrs. Dunlop Rubber Co. (India) Ltd., Delhi, for trial. The vehicle was tested and a report has been sent on its working. It was found more useful on metalled roads than on field or *kutch*a roads.

Country implements, like *kariba* of Baroda, blade-hoe of Poona and Bhaltuact-harrow of Dholka, which are cheap and easy to manufacture, proved useful for row-crop cultivation and for producing mulch for the conservation of moisture.

V. CATTLE BREEDING

1. THE PEDIGREE SAHIWAL HERD

At the end of the year the herd consisted of 9 breeding bulls, 78 milch cows, 69 young female stock and 58 young male stock—a total of 214 head.

The condition of the entire herd was excellent throughout the year, and there was no outbreak of any contagious disease among them, except a few sporadic cases of coccidiosis among the pail-fed calves over two months of age. They were treated and cured without a single mortality.

2. MILK YIELD

The milk yield of the milch herd averaged 21·9 lb. against 21·2 lb. of the last year.

Milk yield of the year 1939-40.

Month	Average yield			No. of cows in milk and dry			
	Total yield (excluding stripping)	Per day	Per cow per day	Total No. (milch herd)	In milk	Dry	Percentage of cows in milk
	Lb.	Lb.	Lb.				
July 1939	28,881	932	21·1	64	44	20	68·7
August	28,167	909	21·0	64	43	21	67·2
September	23,793	793	19·6	64	41	23	64·1
October	24,399	787	18·7	66	42	24	63·7
November	22,808	760	19·2	67	40	27	59·7
December	25,894	835	20·8	75	40	35	53·3
January 1940	32,449	1,047	22·3	66	47	19	71·2
February	33,950	1,171	24·2	69	48	21	69·6
March	36,296	1,171	23·2	75	54	21	72·2
April	39,446	1,312	23·9	78	55	23	70·5
May	43,438	1,401	24·3	78	58	20	74·4
June	41,489	1,383	23·4	74	59	15	79·7
Average	31,751	1,042	21·9	70	48	22	67·8
Average for 1938-39	25,613	842	21·2	65	40	25	61·4

Average yield per cow, per day, of second calvers was 20·0 lb. and that of heifers 20·6 lb. as against 18·6 lb. and 18·2 lb. respectively for the year 1938-39.

The performance of some of the best cows and heifers are given below :—
Some of the best cows and heifers which completed lactation during 1939-40.

Serial No	Name and No	Date of birth	No. of calvings	Lactation	
				Lb.	(Days)
Cows					
1	Laruli, 604 . . .	20-10-1929 . .	5	11,046	306
2	Bilamba, 674 . . .	10-12-1932 . .	3	10,004	306
3	Charoochi, 667 . . .	10-9-1932 . .	4	9,450	306
4	Chansuri, 653 . . .	11-3-1932 . .	4	8,890	303
5	Choki, 681 . . .	11-3-1933 . .	4	8,712	306
6	Birbutia, 659 . . .	16-5-1932 . .	4	8,647	306
7	Durdha, 688 . . .	16-4-1933 . .	3	8,520	306
8	Naraee, 705 . . .	22-12-1933 . .	3	8,227	306
9	Lakhram, 753 . . .	11-8-1935 . .	2	7,549	306
10	Bulbul, 814 . . .	9-2-1928 . .	7	7,293	306
11	Chandrama, 569 . . .	14-5-1927 . .	8	7,163	306
12	Cholesari, 717 . . .	16-3-1934 . .	3	7,805	306
Heifers					
1	Rajkhali, 783 . . .	25-10-1936 . .	1	7,320	306
2	Jensuri, 769 . . .	18-3-1936 . .	1	7,220	306
3	Jesmari, 784 . . .	10-11-1936 . .	1	7,175	306
4	Nabrila, 770 . . .	20-3-1936 . .	1	6,940	306
5	Machmati, 782 . . .	23-10-1936 . .	1	6,256	306
6	Onkraee, 773 . . .	3-5-1936 . .	1	5,530	303
7	Onkruli, 779 . . .	9-8-1936 . .	1	5,343	306
8	Jeschakh, 781 . . .	6-9-1936 . .	1	5,090	306
9	Noshnina, 768 . . .	15-3-1936 . .	1	5,043	306

3. PERCENTAGE OF COWS IN MILK AND DRY

For a commercial dairy concern, a regular and constant supply of milk throughout the year is an important factor, and this can only be accomplished if the number of cows in milk is maintained at a constant level of 70 to 75 per cent. Here in the Sahiwal herd, cattle breeding technique has been so well perfected that sterility and holding off are rare. The percentage of cows in milk for the year under report was 67·8 per cent as against 61·4

per cent in the previous year. A comparative statement, showing the rapid progress made in this direction from 1931-32 is given below :—

Year	Average number of cows in the herd *	Percentage of cows in milk
1931-32	79	50.2
1932-33	77	55.1
1933-34	63	66.2
1934-35	54	60.0
1935-36	58	51.5
1936-37	71	44.9
1937-38	73	59.8
1938-39	65	61.4
1939-40	70	67.8

* These averages are based on monthly totals.

4. CALF-REARING

This year it has been possible to rear 76 calves out of 78 born as against 55 calves reared out of 67 dropped in the previous year. As regards the two deaths, one was due to pneumonia in a calf born prematurely, and the other was due to navel-ill. Thus the calf mortality remained at a low level of 2.6 per cent during the year under report. After a trial of the revised scale of milk ration for calf feeding for 2½ years, which is built upon one-tenth birth weight of calves, the calf mortality due to digestive trouble of simplest nature has been successfully eliminated. Under the revised scale of calf feeding it has also been possible to rear calves to a standard weight and size for early maturity experiments.

5. INFLUENCE OF SEASON ON THE SEX OF CALVES

On an analysis of the sexes of calves born during the last 36 years, it is found that generally there is a marked tendency to throw higher percentage of bull calves than heifer calves in all the seasons except in summer and spring when the percentage of heifer calves and bull calves reaches a level of 50 per cent each. In autumn and winter the percentage of bull calves is more than that of heifer calves by 3 to 5 per cent.

The mating season is responsible for the determination of sex and not the season in which they calve. The records also show that the prepotency of a bull has more to do with the determination of sex than seasons of the year. The stud bull Nala, a getter of male calves, is responsible for throwing eight male calves as a result of mating him in spring, summer and autumn.

A statement showing the seasonal influence on the sex of calves is given below :—

Season of birth	1904-40		1938-39		1939-40	
	Percentage of sex		Percentage of sex		Percentage of sex	
	Bull-calf	Cow-calf	Bull-calf	Cow-calf	Bull-calf	Cow-calf
Winter . .	52·8	47·2	57·1	42·8	53·3	46·6
Spring . .	50·8	49·1	50·0	50·0	57·1	42·8
Summer . .	50·0	50·0	22·2	77·7	50·0	50·0
Autumn . .	51·6	48·6	57·1	42·8	69·2	30·7
Average .	51·3	48·7	46·6	53·3	57·4	47·5

6. EARLY MATURITY EXPERIMENTS

In the beginning, investigations were conducted on heifers which reached maturity within 13 months to 2 years age; further experiments were conducted to fix a standard early maturity age for mating purposes. The results indicated that early mating age should have been considered in relation to their growth and development with a definite body weight within the early maturity age. As a result of these findings, experiments were started two and a half years ago to find out a standard size which would be in direct relation to early maturity age. Experiments were then conducted on heifers showing two-thirds of adult body weight at any age within the limit of early maturity age. As 900 lb. is the average standard body weight for cows of this pedigree Sahiwal breed, 600 lb. has been fixed as the standard body weight for mating heifers, irrespective of any earlier age at which they mature. The heifers which were mated on this basis and calved during this year showed that their growth was not retarded in any way during the gestation period. They also did not show any inability to develop and throw a normal calf of an average weight, and their calving conditions were not such as to give any anxiety for poor performances. Twenty-eight heifers calved during the second half of the year and many of them have already done over 3,000 lb. of milk by the middle of their lactations, and their present daily average yield is as high as 24 lb. per heifer per day.

It was quite evident that the high efficiency in the majority of the present lot of early maturity heifers could be made possible when the mating body weight did not fall below the standard weight of two-thirds average

adult body weight, and the poor efficiency in one way or other was also evident in those animals where the mating weight was far below or far above the new standard weight.

7. SALE OF CATTLE

The statement of cattle sold during the year under report is given below :—

Particulars	No.	Total price	Average			Average for 1938-39		
		Rs.	Rs.	A.	P.	Rs.	A.	P.
1. Cows	16	3,325	207	13	0	185	9	0
2. Bulls	2	1,650	825	0	0	1,500	0	0
3. Young bulls	21	3,765	179	5	0	91	9	0

Five animals were sold at normal prices.

Several orders were received from Kenya, Jamaica, and Costa Rica for pedigree young Sahiwal bulls. An order for three young bulls for Rs. 1,300 from the Veterinary Department of the Government of Kenya was executed during the year, and a further order for four more young bulls is being arranged for shipment. It is evident from these inquiries from abroad that in the very near future there will be a great demand for young bulls of best Indian milch breeds. This will solve the present problem regarding the disposal of young male stock of all Indian milch breeds to the best advantage of the Indian milch cattle breeding industry.

8. RECEIPTS

An amount of Rs. 26,349-9-0 has been realised from the sale of dairy produce and cattle against Rs. 22,224-13-0 of the previous year. The income from the dairy produce alone fetched Rs. 17,512 as compared with Rs. 14,345 in the previous year. The steady increase in the receipts, year after year, particularly in the last four years, stands as an evidence of the highest efficiency at which the cattle breeding operations are being conducted at this Institute.

The annual statement of live-stock is given below.

Description of cattle	Balance on 1st July 1939	Increase		Decrease				Balance on 30th June 1940
		By birth	By trans- fer	Sent to pinj- rapole	By death	By trans- fer	By sale	
Bulls	10	..	4	..	..	2	3	9
Cows	68	..	56	3	2	22	19	78
Young male stock .	48	44	26	..	6	30	24	58
Young female stock .	69	34	..	..	..	34	..	69
Bullocks	4	..	..	..	..	..	..	4
Total	199	78	86	3	8	88	46	218

VI. PROGRAMME OF WORK FOR 1940-41

Work will be continued mostly on the same lines as during 1939-40

2. Agricultural Substation, Karnal

I. FARM

The total area of the Substation is 2,154 acres, out of which 51.42 acres remained under the control of the Sugarcane Expert. The area under direct cultivation was 1,268.68 acres, while 345.50 acres were leased out for cultivation and grazing.

The main storm-water drains have been remodelled, and it is proposed to construct other connective drains which would carry water from fields to the main drains, as soon as funds are available. Other improvements of the farm consisted of metalling the farm roads, repairing troughs and culverts, construction of sluice gates in the fields and remodelling of Block No. 6.

There has been considerable difficulty in obtaining adequate irrigation water supply due to the remodelling of the out-let made by the Canal Department at the Karnal fall. If the discharge is not going to be increased substantially, most of the area controlled by this out-let will have to be converted into *barani*. During the year under report, 437.5 acres in *kharif* and 914.5 acres in *rabi* were irrigated. The canal was closed for one and a half months at the end of March, and this had an adverse effect on the yield of berseem crop.

II. CROPS

1. RAINFALL AND CROP YIELDS

The total rainfall during the year under report amounted to 13.91 inches as against 21.36 inches in the previous year and 23.55 inches in 1937-38. As a result of improved agronomy, the effect of poor rainfall was

not apparent on the yield of most of the *rabi* crops, and an outturn better than that of last year was obtained from the same crops. The yields of crops under direct cultivation are given below and those of the previous year are given in parentheses.

Statement of crop yields during 1939-40

Crops	Area in acres	Yields in maunds	
		Total	Average per acre
Maize	2·24	11·50	5·13 (12·11)
Jowar	21·55	53·85	2·50 (9·16)
Meth	20·31	118·83	5·85 (13·29)
Soybean	8·84	36·65	4·15 (9·82)
Cowpeas	27·38	41·26	1·50 (4·82)
Sannhemp—seed	18·56	66·53	3·58 (4·73)
Guar	2·10	13·65	6·50 ..
Paddy	100·22	1,968·83	19·65 (24·18)
Oats	324·45	7,429·20	22·90 (14·70)
Wheat	194·22	4,066·06	20·93 (15·59)
Barley	26·93	540·35	20·06 (20·04)
Gram	248·84	3,711·43	14·91 (10·54)
Peas	10·50	203·00	19·33 (25·21)
Linseed	3·30	19·04	5·77 ..
Lentil	0·68	7·06	10·37 ..
Flax-seed	5·10	27·15	5·32 (9·96)
Berseem-seed	10·30	22·65	2·20 ..

The incidence of all forms of rust on wheat was mild this year as compared with previous years ; I. P. 165, I. P. 80-5, I.P. 120 and I. P. 111 were free from this disease. Except in a plot in Block No. 5-west near the silo tower, gram wilt was not severe on the farm this year. Oats I. P. 1 was badly affected by smut. It is proposed to treat the seed before sowing next season.

2. CROPPING OF THE FARM

The area under direct cultivation has been divided into (i) experimental area comprising the fenced portion of Block No. 4 and the general area, (ii) fodder area consisting of 498 acres in Block Nos. 5 & 6 in the proximity of the cattle byre, and (iii) seed multiplication area which comprises the rest of the area. Items (ii) and (iii) also constitute the mixed and mechanised farming unit.

3. MANURING

On an extensive farm like Karnal, the question of maintaining fertility of the land was becoming acute for some years due to the shortage of farm-yard manure. The use of artificial fertilizers and oil cakes was found to be expensive. Green-manuring, though a cheaper method of adding humus to the soil, was not practicable over an extensive area, especially when the rainfall was so scanty for the last three years.

This year large-scale composting has been started by utilising cheap waste material of the farm. The results obtained so far are very encouraging. There are now 33 pits in all on the farm, and 15,802 maunds of compost was made at a cost of 6.26 pies per maund including the expenses for carting.

4. FIELD EXPERIMENTS AND MISCELLANEOUS WORK ON CROPS

(i) A field experiment was conducted to study the effect of artificial fertilizers on seed production and early maturity of seed in berseem. The results so far obtained indicate that (a) superphosphate alone and (b) a mixture of superphosphate and sulphate of ammonia give more yield than sulphate of ammonia. The seed, however, ripened one week earlier in plots treated with superphosphate.

(ii) The results of the seed production experiment by taking different cuttings of berseem are given under "Field Experiments" in the first part of this report.

(iii) The manurial experiment with artificial fertilizers on paddy as given in the last year's report was concluded this year. The results of the three years' experiment show that sulphate of ammonia when used alone gave equally good results as compared with the mixture of nitrate of soda and sulphate of ammonia.

(iv) A cultural experiment was conducted this year to see the comparative effect of (a) steam tackle implements, (b) tractor implements, (c) victory plough and (d) country plough on the yield of wheat. The results show that $a > b, c \text{ \& } d$; $b > d$; $b = c$ & $c = d$. Further details regarding this experiment will be found in the third part of this report under "Investigations—Estimation of yields".

(v) The study of cowpeas was continued on the lines reported in 1937-38. A few fodder and grain types suitable for this tract have been selected, and they will be tested for yield.

(vi) A number of new types of *meth* (*Phaseolus aconitifolius*) suitable for fodder and grain have been isolated and are being multiplied.

5. SEED DISTRIBUTION

The following quantities of seeds were distributed during the year under report.

Crops	Quantity Mds
Wheat	712.38
Gram	962.15
Oats	828.55
Peas	53.63
Berseem	9.15
Cowpeas	6.23
Flax	28.00

III. TRACTORS AND MACHINERY

The use of Fowler's steam tackle was restricted to plots badly infested with deep-rooted weeds and to cultural experiments, as it has become very old and expensive for ordinary cultivation.

The two McCormick diesel tractors which were purchased in 1936 worked satisfactorily throughout the year. A new tractor of the same model was purchased during this year at a cost of Rs. 7,600. The details of working and analysis of cost are given below.

W. D. 40 McCORMICK DEERING TRACTORS

Summary of work done

Tractor No.	Working hours	Ploughing		Disc-harrowing		Harrow-ploughing		Grubbing		Drilling		Transport and idle run (hours)
		Hours	Acres	Hours	Acres	Hours	Acres	Hours	Acres	Hours	Acres	
1614	826.50	150.00	180.43	257.25	586.24	129.50	267.85	197.25	570.37	35.25	73.50	57.25
1612	690.50	42.75	48.00	160.25	432.18	64.25	136.66	378.75	1183.70	..	..	44.00

Acres per hour

Tractor No.	Ploughing		Disc-harrowing		Harrow-ploughing		Grubbing		Drilling	
	Hours	Acres	Hours	Acres	Hours	Acres	Hours	Acres	Hours	Acres
1614	1.20	1.20	2.28	2.07	2.89	2.08	2.89	3.13	2.08	..
1612	1.12	1.12	2.70	2.13	3.13	..	3.13	..	..	..

Consumption

Tractor No.	Light Diesel oil		Kerosine oil		Petrol		Engine oil		Grease		Waste cotton	
	Total Gal.	Per hour Gal.	Total Gal.	Per hour Gal.	Total Gal.	Per hour Gal.	Total Gal.	Per hour Gal.	Total lb.	Per hour lb.	Total lb.	Per hour lb.
1614	1652.0	2.00	50.31	.06	24.0	.03	90.00	.11	240.50	.30	65.50	.08
1612	1408.0	2.04	41.37	.06	20.0	.03	76.00	.11	171.50	.25	56.00	.08

Depreciation and interest

Tractor No.	Total working hours (including belt pulley work)		Cost purchase price of tractors		Value on 1st July 1939		Depreciation		Interest at 6 per cent per annum	
	Total hours	Rs.	Estimated life	Hrs.	Rs.	Rs.	Rs.	Rs.	per cent	Rs.
1614	1020.50	7152.50	8,000	8,000	4548.85	912.39	272.9310	272.9310	..	272.9310
1612	997.00	7152.50	8,000	8,000	4436.78	891.38	266.2068	266.2068	..	266.2068

Analysis of total cost on cultivation

Tractor No.	Working Hrs.	L. D. oil		K. oil		Petrol		Lubri- cants and waste		Drivers carriers		Repairs and water and sun- dries		Spare parts		Depre- cia- tion	Interest	Total	Expenses per hours
		Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.				
1614	826.50	739.96	48.21	39.00	279.05	162.28	82.14	253.08	738.94	221.05	2563.71	3.102							
1612	690.50	630.67	39.65	32.73	225.53	174.32	88.57	383.00	617.35	184.37	2376.19	3.441							

Cost per acre						
Tractor No.	Ploughing	Disc- harrowing		Harrow- ploughing	Grubbing	Drilling
		Rs.	Rs.			
1614	2.59	1.36	1.50	Rs.	Rs.	Rs.
1612	3.07	1.27	1.62	1.62	1.07	1.49
					1.10	..

Cost per acre

Tractor No.	Ploughing		Disc- harrowing		Harrow- ploughing		Grubbing		Drilling	
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
1614	2.59	1.36	1.50	1.07	1.49	1.07	1.49	1.07	1.49	1.49
1612	3.07	1.27	1.62	1.10	..	1.10	..	1.10	..	..

One old and two new Marshall threshers were worked during the year. The old thresher, though considerably worn out, did good work at a low cost. The new 32" Marshall thresher purchased last year also proved useful for small out-put. The new 42" Marshall thresher fitted with a bruiser was received from the makers this year. The following points were noticed in the working of this machine.

(i) There are wide gaps between the shakers due to which straw passes into the riddles and ultimately results in jamming the machine.

(ii) Due to frequent breakage of teeth of the bruiser, there was a regular interruption in the work.

The machine was, otherwise, found to be quite useful. The cost of threshing wheat by this thresher amounted to As. 8-10 per maund including interest and depreciation.

Three out of the five old thistle mowers were used for harvesting during the year under report, and their work was not satisfactory. One new McCormick Deering No. 7 mower was purchased this year and was very useful for harvesting *rabi* crops.

The ensilage cutters, though old, worked satisfactorily.

IV. CATTLE BREEDING

1. THE PEDIGREE THARPARKAR HERD

The herd consisted of 10 breeding bulls, 83 milch cows, 85 young female stock and 58 young male stock, a total of 236 head at the end of the year. Preventive inoculation against haemorrhagic septicaemia was carried out on the whole herd and on bullocks. 84 young stock were also inoculated against rinderpest with goat virus. 30 animals were rejected and sold.

2. BREEDING POLICY

After the All India Cattle Show held in New Delhi in 1939, when the animals exhibited from this herd were judged as not belonging to the pure Tharparkar breed, a meeting was convened for defining the characteristic points of this breed. But so far, the committee has not come to a definite decision, and consequently no standard type for breeding could be fixed. This has adversely affected the sale of animals for breeding purposes. The present programme for breeding has been to bring about the most desirable characteristics of a good milch breed.

It is, however, satisfying to note that Tharparkar animals exhibited from this herd at the All India Cattle Show in 1940 were approved by the judges as Tharparkars. Out of twelve animals presented, five were awarded prizes.

3. MILK YIELD

There was an improvement in the average milk yield over the last year as is evident from the table given below :—

Statement of milk yield for the year 1939-40

Months	Average yield per cow per day in lb.		Months	Average yield per cow per day in lb.	
	1938-39	1939-40		1938-39	1939-40
July	21.0	21.1	January	16.7	19.1
August	20.9	20.6	February	18.7	18.9
September	20.3	19.1	March	18.4	20.2
October	18.8	17.6	April	18.7	20.9
November	17.2	17.5	May	21.8	20.5
December	16.0	18.8	June	21.5	21.2
			Average	19.2	19.6

The average milk yield of cows which completed their full lactations during the year is given together with those obtained in the two previous years.

Milk yield of cows which completed their lactations during the last three years

Year	No. of cows	Average milk yield Lb.	Average No. of days in milk
1937-38	56	5,716	284.1
1938-39	60	5,590	281.0
1939-40	58	5,277	277.0

The records of six best cows and six best heifers are given below :—

Records of best cows and heifers during 1939-40

Name and No.	No. of calv- ings	Milk yield lb.	Days in milk
<i>Cows—</i>			
Kumari, 36	6	10,014	306
Katni, 44	7	8,096	305
Kobi, 46	7	7,722	300
Sidhi, 58	5	7,899	305
Bakhto, 61	5	7,693	305
Machkani, 105	2	9,041	305

Name and No	No. of calv-ings	Milk yield lb.	Days in milk
<i>Heifers—</i>			
Ramshi, 147*	1	4,458	304
Mahabiri, 145	1	4,472	304
Lani, 161*	1	5,039	306
Utakni, 162*	1	4,868	305
Qabdi, 172*	1	4,968	305
Urji, 158	1	4,344	305

*Early maturity heifers.

4. EXPERIMENTS ON THE HERD

A number of experiments, *viz.*, handling, pre-milking, special feeding, early maturity and four times milking were in progress. The bago-mollascuit feeding experiment was continued on bullocks. All the animals which calved during the year responded well to pre-milking and handling as practised on the Delhi herd.

5. CALF REARING

There were 76 births during the year, and all calves were weaned at birth and reared by pail feeding. Out of 151 calves reared during the year, 12 died of ordinary ailments and 4 from infectious diseases.

6. STATEMENT OF LIVE-STOCK FOR THE YEAR 1939-40

Particulars	Balance on 1-7-39	Increase		Decrease			Balance on 30-6-40
		By transfer	By birth	By death	By sale	By transfer	
Bulls	8	3	..	..	1	..	10
Cows	82	21	..	2	18	..	83
Young female stock	86	..	41	11	10	21	85
Young male stock	55	..	35	6	1	25	58
Total	231	24	76	19	30	46	236

3. Statistical Branch

(P. V. KRISHNA IYER)

1. REVIEW OF LONG-TERM ROTATION EXPERIMENT AT PUSA

The records of the rotation experiment carried out at Pusa on an area of 413 acres were gone through, and the average yield per acre for the various

crops involved in the rotation (described below) was worked out and is given in the accompanying table.

Description of rotation followed

	1st year	2nd year	3rd year
Monsoon crop (<i>Kharif</i>)	Maize for silage and fodder.	Maize for corn	Green pulses for grazing
Winter crop (<i>Rabi</i>)	Oats	Arhar (<i>Cajanus indicus</i>)	Oats

The fields were manured with farmyard manure or oil cake at 10 tons per acre in the first year before sowing maize and with double superphosphate at one maund per acre in the third year before sowing oats.

Average yield per acre in maunds

Year	Maize corn (grown with arhar)	Arhar (grown with maize)	Oats	Maize green fodder
1912-13	5.85	6.25	20.18	171.62
1913-14	4.74	6.34	14.92	201.38
1914-15	9.88	8.79	13.72	133.59
1915-16	8.27	10.10	19.83	214.07
1916-17	7.30	6.25	15.23	164.87
1917-18	12.79	10.29	13.69	192.67
1918-19	8.59	13.04	13.26	217.89
1919-20	9.21	5.85	12.96	156.10
1920-21	8.44	6.69	13.31	156.39
1921-22	9.27	7.73	16.97	264.66
1922-23	7.78	6.49	17.87	118.33
1923-24	8.42	9.88	9.88	186.40
1924-25	3.39	7.35	22.13	95.50
1925-26	5.73	10.63	18.85	136.14
1926-27	6.07	4.88	15.57	91.56
1927-28	10.70	4.78	16.78	217.31
1928-29	12.13	12.25	20.37	131.55
1929-30	9.72	13.50	21.45	151.00

From the above table it is clear that there is no deterioration in the fertility of the area as judged from the yields of the different crops involved in the rotation.

II. INVESTIGATIONS

1. SAMPLING EXPERIMENTS

(a) *Estimation of percentage of canes attacked by different sugarcane pests.*—The main object of the investigation was to fix a sampling method which would give a variance as low as possible for the percentages calculated from the

observed sample. The data used for this purpose were collected at the time of harvest by the Biological Control Research Officer during the course of his *Trichogramma* experiments at two of the Bettiah Farms situated in Lalseriah and Madhopur villages near Sagauli in Bihar in the year 1939-40.

At Madhopur, two ten-acre blocks under Co. 213 (rows 3 ft. apart) were under the constant observation of the Biological Control Research Officer. One of these blocks was kept as control and in the other *Trichogramma* was released to control stem and root borers. A similar experiment on two seven-acre blocks under Co. 313 (rows 2.5 ft. apart) was in progress at Lalseriah also.

At the time of harvest all the blocks were divided into plots of about one acre each and one per cent of the canes from every one of the plots was examined for pests by taking at random ten per cent of the clumps available from ten per cent of the rows. The canes attacked by the different pests were noted for every row separately for the different plots. Further details regarding this experiment will be found in the Second Entomologist's report for the year 1939-40.

The means, their standard errors and the variances for the percentages calculated on the basis of canes obtained from different sampling units, *viz.*,—(i) row; (ii) one-acre block and (iii) two-acre block (for Madhopur only) were worked out and are given below :—

Means, Standard Errors and Variances of the percentage of canes attacked by pests for different sampling units.

Madhopur—Co. 213

Canes infested by	<i>Experimental plots</i>					
	Row basis		1-acre block basis		2-acre block basis	
	Mean and S. E.	Variance	Mean and S. E.	Variance	Mean and S. E.	Variance
1. Free from pests	25.77 ±0.97	79.36	25.68 ±1.42	20.14	25.75 ±1.83	16.79
2. Top borer	50.52 ±1.47	180.61	50.82 ±2.78	77.51	50.75 ±3.27	53.37
3. Stem borer	3.84 ±0.39	12.65	3.79 ±0.69	4.70	3.80 ±0.92	4.24
4. Root borer	1.64 ±0.34	4.90	1.66 ±0.29	0.84	1.67 ±0.41	0.82
5. Top and stem borers	7.20 ±0.61	30.75	7.10 ±1.12	12.44	7.09 ±1.56	12.17
6. Top and root borers	6.39 ±0.52	22.97	6.35 ±0.87	7.65	6.31 ±0.95	4.55
7. Stem borer and all its combinations	12.23 ±0.91	69.61	12.03 ±2.10	43.94	12.08 ±2.85	40.69
8. Root borer and all its combinations	9.23 ±0.68	38.39	9.15 ±1.23	15.19	9.18 ±1.31	8.56
No. of samples taken		84		10		5

Control plots

Canes infested by	Row basis		1-acre block basis		2-acre block basis	
	Mean and S. E.	Variance	Mean and S. E.	Variance	Mean and S. E.	Variance
1. Free from pests . . .	17·14 ±0·73	45·12	17·02 ±0·72	5·19	16·94 ±0·72	2·58
2. Top borer . . .	34·93 ±1·16	113·94	35·10 ±2·51	63·11	35·02 ±1·33	8·83
3. Stem borer . . .	1·36 ±0·29	7·16	1·24 ±0·31	0·99	1·26 ±0·25	0·33
4. Root borer . . .	4·89 ±0·47	18·52	4·85 ±0·73	5·26	4·85 ±0·73	2·67
5. Top and stem borers . .	12·09 ±0·63	33·18	12·20 ±1·11	12·21	12·11 ±1·10	6·07
6. Top and root borers . .	25·52 ±1·19	118·89	25·66 ±2·50	62·74	25·82 ±1·68	14·19
7. Stem borer and all its combinations	14·69 ±0·64	34·88	14·79 ±1·16	13·36	14·64 ±0·75	2·78
8. Root borer and all its combinations	31·65 ±1·27	134·91	31·75 ±2·66	70·63	31·94 ±1·39	9·71
No. of samples taken . . .		84		10		5

*Means, Standard Errors and Variances of the percentage of canes attacked by
pests for different sampling units*

Lalseriah—Co. 313

Canes infested by	Experimental plots			Control plots		
	Row basis		1-acre block basis	Row basis		1-acre block basis
	Mean & S. E.	Variance	Mean & S. E.	Mean & S. E.	Variance	Mean & S. E.
1. Free from pests .	31.65±0.80	35.53	31.60±0.95	20.27±0.91	50.80	19.66±1.51
2. Top borer .	34.93±0.86	41.60	34.90±1.19	10.96±0.84	43.34	10.91±1.87
3. Stem borer .	3.54±0.24	3.28	3.57±0.18	5.48±0.50	15.51	5.59±0.44
4. Root borer .	4.22±0.42	9.86	4.20±0.65	15.07±1.12	76.04	14.80±1.70
5. Top & stem borers	5.20±0.38	7.90	5.23±0.58	17.60±0.78	37.01	17.70±1.55
6. Top & root borers .	15.52±0.69	26.30	15.54±0.70	21.84±1.02	63.49	22.37±1.61
7. Stem borer & all its combinations	10.20±0.40	8.99	10.23±0.67	29.36±0.96	55.93	29.71±1.65
8. Root borer & all its combinations	21.18±0.86	41.48	21.17±1.04	43.19±1.12	76.58	43.60±1.88
No. of samples taken	56		7	61		7

From the above tables it will be seen that the variances for one-acre and two-acre block sampling units are considerably less than for row sampling, and hence the best method of sampling to obtain information regarding the incidence of pests from fairly extensive areas is by taking samples on the basis of one-acre or two-acre units. It may be noted that the reduction in the variance has not resulted in an increase in the precision of the means. This is accounted for by the considerable reduction in the replications available for the means. Evidently, this can be made up by increasing the replications.

(b) *Estimation of yield.*—At Karnal, four big rectangular blocks under wheat, cultivated with steam tackle, tractor, victory plough and *desi* plough, were harvested by taking two samples each 100 ft. $\times$ 100 ft. at random from each of the plots formed by the diagonals of the blocks, (i.e., eight samples were taken in all from each block). The actual and the estimated yields obtained by the sampling procedure are compared below ;

Description of treatment	Area under different treatments (Acres)	Average yield in maunds per acre	
		Actual after whole area harvested	Estimated on sampling basis
1. Steam tackle	25.14	25.10	25.05 $\pm$ 1.25
2. Tractor	14.33	21.01	23.47 $\pm$ 1.17
3. Victory plough	10.00	19.04	20.94 $\pm$ 1.08
4. <i>Desi</i> plough	10.00	17.70	19.03 $\pm$ 1.08

The above table shows that the differences between the actual and the estimated values are within the limits of error.

2. BALANCED *VERSUS* RANDOMIZED ARRANGEMENTS FOR FIELD EXPERIMENTS

In my report for 1937-38, the variances obtained from a number of randomized and balanced lay-outs were examined, and it was found that both the layouts gave practically the same residual error. The Karnal wheat uniformity trial data, of which mention has been made in the 1938-39 report, were used to get more information on this point. Balanced and random arrangements were formed with dummy treatments for experiments involving 4, 5, 6 and 7 treatments replicated 6, 6, 8 and 6 times respectively. The arrangements taken were such that it was possible to have only one systematic balanced layout and a large number of random ones. A large number of random

samples were taken for each experiment and the residual variances obtained were compared with that of the balanced ones. A brief summary of the results obtained is given below in a tabular form :

No. of treat- ments	No. of replica- tions	Plot size	No. of rando- mized samples taken	No. of samples whose residual variance was	
				greater than balanced arrange- ments	less than balanced arrange- ments
4	6	15' × 15' . . .	300	240	60
5	6	15' × 15' . . .	400	357	43
6	8	15' × 15' . . .	400	238	162
7	6	15' × 20' . . .	400	314	86

From the above table, it is clear that the late Mr. Gosset's contention that a balanced arrangement is likely to give greater residual variance than randomized ones does not hold good, and hence randomized arrangements appear to be preferable to balanced lay-outs. Further work is in progress.

3. DISTRIBUTION OF RATIO OF VARIANCES

The variance ratio test which is generally used to judge whether the difference between two variances is significant or not, is based on the assumption that the distribution of the population from which samples are drawn is normal. It is not definitely known whether these tests are valid when the distribution of the population is not normal. At Rothamsted* the validity of the z-test, when the distribution was not normal, was investigated, and it was found that the probability of the observed z-distribution being the same as the theoretical distribution for a particular set of observations was greater than 0.30 and less than 0.50. Investigations on this point were carried out by calculating the ratio of variances of treatments and residual error for the random samples mentioned in the previous section. The observed frequency distribution for the ratio of variances was compared with the theoretical distribution by calculating ' χ^2 '. The probability for the two distributions being the same is noted below.

No. of treatments										Probability
4	.	.	.	.	.	.	.	.	.	0.734
5	.	.	.	.	.	.	.	.	.	0.165
6	.	.	.	.	.	.	.	.	.	0.934
7	.	.	.	.	.	.	.	.	.	0.091

The above figures show that the variance ratio test as judged from an uniformity trial is valid for field experimental data. Further details of this investigation will be published separately.

*Eden, T. and Yates, F. (1933)—*J. Agri. Sci.* **23**, 6—17.

4. ANALYSIS OF COMPACT EXPERIMENTS WITH THREE AND FOUR RESTRICTIONS

The method of analysis of experiments involving three and four restrictions was investigated carefully, and it was found that the method suggested by Paterson* would require some modifications. The main point to be noted in this connection is that the sum of squares calculated in the usual way will be orthogonal to each other *for only* two restrictions. Others are not independent of the first two restrictions, and hence corrections are to be made in evaluating the sum of squares due to the additional restrictions.

The plan of a layout together with the yield of barley obtained, and the method of analysis to be followed are given below in brief.

Yield of Barley I. P. 13 per plot in lb.

R

M	I 28.25	G 27.25	B 26.50	E 41.00	F 51.50	C 54.00	X
	A 42.00	J 28.75	D 27.50	H 36.00	L 37.75	K 52.00	
	E 47.25	L 44.25	K 55.25	J 57.75	I 66.00	A 59.25	
W	H 29.25	C 26.75	F 39.50	G 30.75	D 46.75	B 54.75	Z
	L 25.00	D 22.75	H 25.00	C 31.50	J 39.00	E 46.25	
N	G 25.00	B 26.25	A 28.50	I 32.75	K 34.75	F 50.25	Z
	C 36.50	K 39.75	J 36.50	L 46.00	B 36.75	D 33.25	
Y	F 21.75	I 28.50	E 50.25	A 30.25	H 27.50	G 35.25	Z
	K 21.25	H 22.75	C 17.75	F 21.50	G 21.75	L 28.00	
O	B 12.50	E 12.00	I 17.00	D 14.75	A 12.25	J 20.50	Z
	J 19.50	A 19.00	L 15.25	B 17.50	E 18.00	I 23.00	
	D 26.50	F 19.75	G 21.25	K 19.00	C 19.50	H 27.50	
P							Q

*Paterson, D. D. (1933)—*Trop. Agri.* 10, 303—307.

Restrictions :—

I.—Along columns

II.—Two rows taken at a time, i.e., 1 & 2, 3 & 4, 11 & 12.

III.—Blocks formed by joining RS, WX & YZ.

The sums of squares for restrictions I and II and treatments are obtained in the usual way. The sum of squares for the third restriction is equal to the usual s. s. for the restriction—s. s. due to sections P & Q—s. s. due to sections M, N and O ; the degrees of freedom being $5 - 1 - 2 = 2$. The final analysis of variance table is as follows :—

Analysis of variance

Variance due to	D. F.	S. S.	M. S.	Ratio of variances	
				Observed	Theoretical at the 5 per cent level
Blocks (2×6)	5	6797·95	..	..	..
Blocks (1×12)	5	1509·53	..	..	..
Blocks (3×4)	2	451·15	225·57	4·603	3·19
Treatments	11	661·22	60·11	1·227	
Residual	48	2352·39	49·01		
Total	71	11772·24			

It may be noted that the elimination due to the third restriction is significant at the 5 per cent level.

Further details will be published in the Indian Journal of Agricultural Science 1940.

REPORT OF THE IMPERIAL ECONOMIC BOTANIST

(B. P. PAL)

I. INTRODUCTION

Further progress was made in the evolution of varieties possessing disease resistance and other desirable qualities. The policy of laying increasing stress on genetical and cytogenetical studies and on problems of fundamental interest has been continued.

The following sub-stations, financed by the Imperial Council of Agricultural Research, are under the control of the Imperial Economic Botanist :—

- (i) Botanical Sub-station, Pusa.
- (ii) Potato and Wheat Breeding Sub-station, Simla.
- (iii) Tobacco Research Sub-station, Guntur.

The work done at these sub-stations during the year is given in detail in the reports on these sub-stations submitted separately to the Imperial Council of Agricultural Research ; the salient features of the experimental work are given under the appropriate sub-heads in the present report.

As in previous years, a large number of enquiries were received from correspondents regarding varieties of crops, methods of cultivation, curing, etc., and the information asked for was supplied.

II. RESEARCH.

1. BREEDING FOR DISEASE RESISTANCE AND OTHER CHARACTERS

WHEAT (*Triticum vulgare* Host)

Rust resistance.—Breeding for rust resistance was continued at the Sub-station at Simla, with the co-operation of Professor K. C. Mehta. The F₅ generations of nine crosses between resistant foreign varieties and important Indian varieties were grown. Out of 2,794 seedlings tested with mixtures of all the physiologic races of the three rusts occurring in India, 1,694 proved to be resistant. The hybrids were tested later in the season for adult resistance also. The F₁ generations of several new crosses were grown ; crosses between Steinwedel (*T. vulgare*) and Khapli (*T. dicoccum*) and between Steinwedel and *T. Timopheevi* were partially fertile. Attempt was made to backcross these and other sterile or partially sterile hybrids. The previous year's endeavour to backcross the sterile wheat-rye hybrid (I. P. 120 × rye) having failed, the cross was repeated this year and will be studied next season. A complex cross was also made with the object of synthesising high resistance to all the three wheat rusts into a single variety.

The study of a large collection of foreign and indigenous wheats (including hill varieties) with the object of discovering resistant forms suitable for use in breeding was continued. A variety received from Kenya (Accession No. E.-144) has been found to be highly resistant to the physiologic races of black

rust ; another Kenya variety (E. 148) is highly resistant to all the races of yellow rust. These varieties are being used for breeding.

Another study has been undertaken at the Simla Sub-station with the object of correlating rust resistance with easily determinable morphological and other characters, and thereby facilitating breeding for rust resistance. Special attention is being paid to the time of opening of the stomata, and the relative proportions and disposition of sclerenchyma and chlorenchyma in the culm.

Smut resistance.—Co-operative experiments were carried out with the Section of Mycology and Plant Pathology to test the resistance or susceptibility of a large number of wheat varieties to loose smut and flag smut. A more detailed reference to these experiments will be found in the report of the Imperial Mycologist.

Drought resistance.—Two hundred and sixty varieties, both Indian and foreign, were grown under dry conditions to test their ability to withstand drought. As a result however of the adequate winter rain, the test was not sufficiently severe and very sharp differences were not observed. Ninety-three varieties gave good yields under these conditions but only thirty-three had really well-filled grain. The trial will be repeated next year.

Non-shedding strains.—Breeding work for the production of non-shedding strains in I. P. 120 and I. P. 114 was continued. The three selections from I. P. 120 isolated last year proved to be not only completely non-shedding but were highly resistant to yellow rust, one of them being as resistant as the original I. P. 120. This strain will be multiplied in the coming season. Selection in I. P. 114 did not however produce the desired result and hence suitable hybridization will have to be undertaken for securing non-shedding strains.

BARLEY (*Hordeum vulgare* L.)

High yield and disease resistance.—A number of high yielding and disease resistant strains with plump grain, stiff straw and other desirable qualities were finally selected at Pusa from the large collection of barleys. They include both 2-rowed and 6-rowed as well as hulled and hull-less (naked) forms.

OATS (*Avena sterilis* L. var. *culta* and *Avena* spp.)

Smut resistance.—From the study of the resistance of the Pusa and some acclimatised exotic oats, conducted during the last few years in collaboration with the Mycology Section, a few strains highly resistant to covered smut (*Ustilago Kolleri* Wille) were selected. Some of the selected strains were grown during the year at Delhi without disinfecting the seeds and all of them proved resistant to smut in as much as they did not contain any affected plants.

PIGEON-PEA (*Cajanus Cajan* (L.) Millsp.)

Wilt resistance.—A number of F_4 families from the cross I. P. 24 $\times$ I. P. 51 and its reciprocal grown at Pusa under wilt infested soil conditions showed a high degree of resistance to wilt (*Fusarium vasinfectum* Atkins) combined with desirable cooking and other qualities. Further selection from this material is likely to produce some very promising strains of this crop. A wilt resistant strain from I. P. 69 was subjected to severe conditions of soil infestation at Pusa in collaboration with the Imperial Mycologist who infested the soil with two strains of the wilt fungus. One of these strains of *Fusarium* appeared to take a heavier toll of the host plants than the other. This experiment will be continued.

LINSEED (*Linum usitatissimum* L.)

Rust resistance.—One hundred and sixty F_6 cultures of crosses between I. P. strains (susceptible to rust, *Melampsora lini*) and resistant exotic varieties were grown at Delhi and Karnal together with the parents. At Delhi there was a slight incidence of disease and only the very susceptible parents were affected. At Karnal, however, there was a heavy incidence of rust. The latter place was chosen because the rust appearing there is a different physiologic form from that known at Pusa, where these selections were grown up to the fifth generation. While the susceptible parents were badly infected, only 3 per cent. of the hybrid cultures were slightly attacked; the remaining cultures and disease-resistant parents were absolutely free from the disease. Further rust-resistant selections have been made.

Fibre and flax.—The cultures from crosses between flax and linseed were grown and selections combining desirable characters both for fibre and seed were made.

POTATO (*Solanum tuberosum* L. and *Solanum* spp.)

Disease resistance.—The breeding of potato varieties resistant to Early Blight, Late Blight, and virus diseases was continued at the Sub-station at Simla. In this work the kind co-operation of the Imperial Mycologist has been obtained. A number of hybrids derived from crosses between Indian and imported varieties have shown high yielding capacity and are relatively resistant under Simla conditions. It is proposed to increase the seed of these and to conduct trials at various centres of potato cultivation in the Provinces.

A survey of virus diseases occurring both in the hills and the plains has shown that there are at least four important virus diseases attacking potatoes. Grafting experiments to determine the relative resistance or susceptibility of important commercial varieties and of the South and Central American potato species to these diseases have been started.

At Delhi, roguing experiments have been carried out on the important "mosaic" disease* (one of the four important diseases mentioned above)

* This has been kindly identified for the writer by Dr. R. N. Salaman as being caused by the potato virus γ (=Solanum virus 2 of Kenneth Smith).

of the *Phulwa* variety and the results show that its incidence can in a short period of time be reduced very considerably by roguing out of the diseased plants.

A new method of producing Late Blight resistant potato varieties was experimented with. Grafts were made between susceptible but otherwise desirable varieties of cultivated potatoes and immune wild varieties, with the object of obtaining chimaeras in which the skin or epidermal layers are of the immune wild variety and the inside tissues are derived from the cultivated parent. If such chimaeras can be experimentally produced, the problem of resistance to Late Blight, and possibly to some other diseases also, may be capable of rapid solution. In this connection a large number of grafts were made but unfortunately all of them died. It is hoped to continue this work next year.

Cold resistance.—The existing commercial varieties of potatoes cannot withstand low temperatures and are killed on freezing. Some of the species from South America are however reputed to be able to withstand several degrees of frost without being damaged. To supplement the results of field tests conducted at Simla where potato material was actually planted in winter, tests were carried out in which potted plants and also separated leaves of varieties of *S. tuberosum* and other species were exposed for varying periods of time to low temperatures in a refrigerator. Among the wild potatoes, two varieties of *S. demissum* were able to stand a temperature of 25-26°F for a period of 8 hours. The most resistant variety of *S. tuberosum* was able to stand such a low temperature for a short duration only. It was also found that plants which had not been watered for some time and had consequently partially wilted withstood low temperatures strikingly better than plants which had received frequent watering.

TOBACCO (*Nicotiana Tabacum* L. and *N. rustica* L.)

High yield and nicotine content.—Work on the isolation of suitable strains of *N. rustica* was continued at Delhi with a view to breeding types with good yield and high nicotine content. Six cultures selected for high yield were under yield trial in a Latin Square. Sun-cured plants from each of these six cultures are awaiting examination for their nicotine contents. On the basis of these results, suitable crosses will be designed and carried out for production of desirable strains. At Pusa a new type of *N. Tabacum*, viz., I. P. 70 (a selection from *Bonhrie*) which has invariably given higher yields and better quality of cured leaves of chewing tobacco was released this year for cultivation. Two exotic cigarette tobacco varieties, viz., *Bonanza* and *Gold Dollar* were successfully cultivated and cured at Pusa. They show good promise of acclimatisation and appear to be less susceptible to leaf curl under Bihar conditions than *Harrison's Special*. At the Tobacco Research Sub-station, Guntur further progress was made with varietal, rotational and manurial trials. The varietal trial has shown that *Bonanza* and *Gold Dollar* compare very favourably with *Harrison's Special* and are worthy of further trials.

1. BREEDING FOR DISEASE RESISTANCE AND OTHER CHARACTERS.

2. GENETICAL AND CYTOLOGICAL STUDIES.

Cytogenetical studies in the oleiferous brassicae

Classification.—With a view to undertaking a cytotaxonomic classification of the cultivated *Brassicae*, an all-India collection of the varieties was made and grown with types maintained at the Section. Detailed morphological descriptions of the cultures were recorded. The chromosome numbers of doubtful species were also determined. One of the cultures raised from seeds obtained from the North West Frontier Province was found to contain many plants with $2n = 38$ chromosomes, a number, so far not found in any of the types grown in India. The plants appear to belong to a European species, *Brassica napus*. Suitable selections from all the cultures were made for further study.

Hybridisation.—The F_1 plants from the several intergeneric and interspecific crosses made during the previous season were under study.

In the intergeneric crosses, three cultivated species of *Brassica*, one of *Eruca*, and a wild species of *Nasturtium* were made use of as parents. Seed setting in crosses between *Brassica* and *Eruca* was poor and the few seeds that were obtained failed to germinate. The cross between *Nasturtium* sp. ($2n = 16$) and *B. nigra* ($2n = 16$), however yielded a considerable number of seeds (about 500) but all of them gave rise to plants resembling the mother parent. Considering the fact that the pollinations were made in the bud stage, taking all precautions to eliminate self pollen, the result obtained is remarkable and provides ample evidence for the existence of pseudogamy in the genus *Nasturtium*. Apomictic development of the egg cell following stimulation by foreign pollen has been known in *Brassica* but not to this high degree as in *Nasturtium*. Embryological studies to ascertain the mode of development of the egg cell under these conditions are under way.

The interspecific crosses were made between species with the same or different chromosome numbers as follows :—

- (1) *B. juncea* ($2n = 36$) $\times$ *B. campestris* ($2n = 20$) reciprocal
- (2) *B. nigra* ($2n = 16$) $\times$ *B. campestris* ($2n = 20$)
- (3) *Brassica* sp. ($2n = 20$) $\times$ *B. campestris* ($2n = 20$)
- (4) *B. napus* var. *dichotoma* ($2n = 20$) $\times$ *B. campestris* var. *sarson* ($2n = 20$)

In the first set of crosses, some maternal plants, a few hybrids and an exceptional triploid hybrid were obtained. While the maternal plants had the same chromosome numbers as those of their respective mother parents, the hybrids had the sum of the gametic chromosome numbers of the two parents, which is, 28. The triploid hybrid which arose from the cross *B. campestris* ($n = 10$) $\times$ *B. juncea* ($n = 18$) had $2n = 38$ chromosomes being made up of two sets of maternal and one set of paternal chromosomes. At metaphase I the maximum association of chromosomes in the diploid hybrids was $10^{II} + 8^I$ and that in the triploid hybrid was $10^{III} + 8^I$. The hybrid

plants were selfed, open pollinated and backcrossed to the parents for further study of the progenies.

In the crosses (2) and (3), only one hybrid plant was obtained in each case, that from *B. campestris* $\times$ *B. nigra* being obtained for the first time. The plants were weak, dwarfish and completely sterile. A cytological study of the hybrids showed partial or complete failure of pairing of the parental chromosomes at meiosis, which contributed to their sterility. It is interesting to notice that the cytological behaviour of the hybrid between *B. campestris* $\times$ *B. nigra* resembled in every respect that of the haploid *rai* isolated last year. This resemblance is significant in connection with the study of the origin of *B. juncea* which is supposed to have arisen from hybridisation of *B. campestris* and *B. nigra* followed by chromosome doubling in the sterile hybrid. Experiments to double the chromosomes of the two hybrids mentioned here, by means of colchicine, will be taken up in the coming season.

A large number of hybrids were obtained from cross (4) and studied with regard to their self and cross compatibilities. The hybrids contained a small percentage of sterile pollen which has been ascertained to be due to chromosome inversion in one of the parental sets. Characteristic chromatin bridges were seen at metaphases I and II in the plants.

Mutations.—(a) Apetalous mutant.—With a view to ascertaining the nature of inheritance of the apetalous condition, a number of crosses between the mutant plant and yellow *sarson* were made and the F_1 plants grown during the year. All the hybrid plants showed the petalled condition to be dominant. A cytological study of the hybrids revealed chromatin bridges at metaphases I and II, indicating the presence of a chromosome inversion in one of the parents. The F_1 plants have been selfed, open pollinated and backcrossed to the parents. The F_2 and backcrossed progenies will be studied in the coming year.

(b) 'Closed petal' mutant.—This peculiar plant with closed flowers, which was isolated last year in one of the cultures of *toria* was crossed with normal plants in the same culture and also with self fertile *sarson* plants. In all cases, the F_1 plants were normal indicating the dominance of this character to the closed petal condition. The F_1 plants were selfed and also crossed among themselves for study of the progenies.

(c) Male sterile mutant.—The sterile mutant in *taramira* was crossed with normal plants and an F_1 generation raised during the year. All the hybrids were normal and had good pollen but were self sterile. Crosses between F_1 plants were made for study of the segregation of the "male steriles" in the next generation. The cytology of the male sterile plant with a view to ascertaining when and how the sterility is brought about, is being worked out.

Variegation.—In the course of our studies several variegated plants in *toria* were isolated. The variegation consisted of a mosaic of green and white

areas on leaves, stems, fruits and even seeds ; sometimes a whole branch was yellow or green. Suitable crosses between variegated and green branches were made with a view to studying the inheritance of this condition brought about by plastid mutation.

Self-sterility.—Experiments to ascertain the mode of inheritance of self-sterility in *toria* were started in 1938-39. Ten plants in one culture were crossed among themselves reciprocally in all combinations. An analysis of seed setting in the different crosses was made and 57 suitable cultures were raised during 1939-40. Crosses between 8 plants in each of four selected cultures were again made in all combinations, involving more than 2,000 pollinations. About 300 plants in the cultures were also selfed. The results of seed setting, on analysis, showed that the inheritance of self sterility in this species is not of the simple "personate" type but of the more complicated "associate" type. An interesting feature in this study was the appearance of a single highly self-fertile plant in one of the cultures which was wholly self-sterile. The breeding behaviour of this plant which appears to be a mutant and of other suitable selections which have been made is expected to throw more light on this problem.

X-ray experiments.—These have been discontinued for the present as sufficient facilities for X-raying seeds were not available.

STUDIES IN POLYPLOIDY

It is well known that polyploidy has played an important part in evolution by bringing about changes of far reaching character in plants ; in addition to increasing the size of organs of the plant, polyploidy and particularly tetraploidy is known to have changed a self-sterile to a self-fertile form, a dioecious to a hermaphrodite race, an annual to a perennial and so on. Therefore the induction and study of polyploidy in crop plants have become of great importance to both practical and theoretical genetics. The recent discovery that colchicine can induce polyploidy in different plant species has given an additional interest and impetus to the study. In this Section, besides a careful watch being kept every year for the spontaneous occurrence of polyploids in the several crops, experiments were also in progress to induce polyploidy in a few species by means of colchicine.

Colchicine induced polyploids.—*Gram*.—During the year 1938-39, 120 seeds of I. P. 25 were subjected to various treatments with colchicine and 26 plants raised to maturity. Of the 26 plants, 13 showed the effect of the treatments in having thicker and broader leaflets, stouter stems, bigger flowers, bigger pods and seeds. The plants were, however, partially sterile as a result of many of the pollen grains and presumably also eggs, aborting. Cytological examination of a few flower buds showed that these plants were tetraploids with $2n = 32$ chromosomes. During the current year, the seeds from different branches of these 13 tetraploids were sown separately and the plants arising from them studied. This year's studies showed that 7 of the original tetraploids were really mixoploids (with $2n$ and $4n$ tissues) and 5 were pure tetraploids. The pollen sterility in the tetraploids varied from 40—70 per cent.

and pod formation and seed setting were sparse. A detailed cytological study of the tetraploids was made. These tetraploids will be grown successively for a number of years for selection of fertile plants.

Chilli.—Similar experiments as with gram were in progress on chillies and during this year progenies of 17 tetraploids, 9 mixoploids and one triploid were under study, besides some diploids which showed varying percentages of pollen sterility during the previous year. This year's results have shown that besides tetraploidy, colchicine also induces mutations and chromosome rearrangements without the duplication of chromosomes. In one diploid culture 6 interchange heterozygotes were obtained and in another a number of tall apparently mutant plants with no change in the chromosomes were also noticed. The work on these plants is being continued.

Tobacco.—Doubling chromosomes in a sterile interspecific hybrid is even more interesting and useful as it restores fertility in the hybrid, conserves its vigour and renders it more suitable for further crossing with other plants. The two tobacco interspecific sterile hybrids namely *Nicotiana Tabacum* ($2n = 48$) $\times$ *N. plumbaginifolia* ($2n = 20$) and *N. glauca* ($2n = 24$) $\times$ *N. plumbaginifolia* ($2n = 20$) which had remained absolutely sterile for over three years were subjected to colchicine treatment for doubling their chromosome numbers. As no seeds were available, growing shoots were subjected to treatment with unsuccessful results so far. The treated shoots in some cases developed leaves with characteristic roughness and fasciation and had larger stomata but later on produced flowers which were as sterile as those on untreated branches and showed no cytological change. Further improved methods are being tried to achieve the object. The cytological study of the two hybrids was also in progress.

Potato.—Seeds of four potato species were subjected to treatment with colchicine of different strengths for different durations and the treated seeds together with the controls have been planted in the field.

Spontaneously occurring polyploids

Natural occurrence of polyploid among crop plants has been reported fairly frequently. At the Botanical Section a few naturally occurring polyploids were isolated and studied as follows :

Pigeon-pea.—Two tetraploid plants were noticed to occur in experimental cultures. They had thicker leaves and bigger flowers and bloomed later than the diploids. They were also highly pollen sterile and produced fewer pods with seeds. A cytological examination of these plants showed that they had $2n = 44$ chromosomes while the diploids had $2n = 22$. The occurrence of tetraploids in this species is recorded for the first time.

Brassica.—Two triploids in *toria* and a haploid in *rai* were also isolated for the first time and studied cytologically. A few seeds set on the haploid plant ($2n = 18$) gave rise to diploids with $2n = 36$ chromosomes. The seeds set on the triploid plants will be sown next year and a study of the distribution of chromosome numbers in the progeny will be made.

Tobacco.—Four plants raised from seeds of *Nicotiana Goodspeedii* obtained from abroad were examined for chromosome numbers. Two plants which were small in stature had $2n = 40$ chromosomes (the number previously recorded for the species) and one which was considerably taller and more vigorous, with bigger leaves and flowers, had $2n = 60$ chromosomes. This plant is obviously a triploid. The fourth plant was slightly different from the other three and had $2n = 32$ chromosomes. This plant may belong to a different species. Work on these plants will be continued.

OTHER GENETICAL STUDIES

Sterility in Potato.—Extensive studies on the different kinds of sterility in potato were in progress. Cases of sterility due to non-flowering, failure of production of male or female gametes, hybridity and incompatibility were met with and studied. The results are being written up.

Variegation: Rice.—The study of the inheritance of the finely variegated type was continued. Segregation in the progenies of heterozygous green plants and in the F_1 s of crosses between variegated and heterozygous greens have confirmed the hypothesis that, in this case, while variegation is a simple mendelian recessive to green, albinism is transmitted only maternally.

One of the rice varieties, *Zenobia*, homozygous for the virescent seedling character was crossed with 'P. 75 with normal green colour of seedlings and the F_1 seedlings were all green indicating the recessive nature of virescence.

Wheat.—Crosses between variegated and normal green plants were made with a view to studying the inheritance of variegation.

Chilli.—The crosses between green and variegated branches of a variegated plant mentioned in the previous report yielded F_1 plants which were all green. An off-season sowing of the selfed seeds of one of the F_1 plants showed a segregation approximating to 12 green : 3 variegated : 1 yellow (lethal). The F_2 families from other hybrid plants will be studied in the coming season for confirmation of the results obtained.

Genetics of gram.—The genetical studies of the two mutants, viz., the tiny-leaved mutant and the simple-leaved mutant were completed and the conclusion that the two mutant characters are recessive to their respective normals but that the latter character is subject to frequent reversal owing to the instability of the gene governing it, was amply confirmed.

Genetical study of an interspecific cross in wheat.—The F_1 of the cross *T. vulgare* Host $\times$ *T. Varilovi* Jakubz. was grown and the mode of inheritance of certain morphological and other characters followed. The results are being analysed.

Mutations

Safflower.—In one of the progenies of a single plant of I. P. 1, six sterile plants in a total of nineteen were observed. The sterile plants had thick, unbranched and twisted stems with thick and leathery leaves. Each plant

bore a solitary terminal capitulum which was devoid of the florets and the receptacle contained a dense mass of bristles. These abnormal plants were absolutely sterile and attempts to propagate them vegetatively did not succeed. Seeds of the normal plants in the segregating cultures and a few seeds of the original heterozygous plant, which is available, will be sown in the coming season for study of the genetics of these plants which might have had their origin in a single gene mutation.

Chilli.—In I. P. 46-A, a mutant plant with short internodes resulting in the production of leaves, flowers and fruits in bunches was isolated. This plant has been selfed and crossed with normal plants for study of the progenies.

Other studies

Asynapsis in chilli.—The cytological study of the asynaptic plant was completed. The few seeds set on this plant from open pollination were sown during 1939-40 and ten plants raised to maturity. Of these, two plants were found to be triploids, two trisomics and six diploids. Pollen meiosis in the triploids showed varying numbers of trivalents, bivalents and univalents. In the trisomics, each with $2n = 25$ chromosomes, at division I the extra chromosome was found to lie outside the metaphase plate as a univalent or was found paired with its homologues forming a trivalent. The progenies of all the ten plants will be studied in the coming season.

Hybrid Vigour.—Heterosis was investigated in both *N. Tabacum* and *N. rustica*, the characters observed being height, size of leaves, time of flowering and yield. The data analysed so far show that in the majority of cases the hybrids were taller than their parents, bore a greater number of leaves and were either earlier than both parents or intermediate in maturity. The *Tabacum* series was also grown under non-irrigated conditions at Pusa; the results were similar to those obtained at Delhi. At Pusa the leaf was flue-cured to see whether the quality had been impaired in any way as a result of the greater vigour of the hybrids. It was found that in several crosses between the cigarette type of varieties, the leaf was equal in quality to that of the better parent.

Notes on hybrid vigour were taken also in chilli, wheat and gram.

3. VERNALIZATION AND PHOTOPERIODISM STUDIES

Experiments on the response to vernalization of different crop plants were continued.

Soybean and chilli.—These were tested for the second year in succession. Since the different temperature treatments tried had no effect, these crops will not be taken up for further testing.

Wheat.—In addition to the three English wheats and two Indian wheats tested in the previous year, some more foreign wheats and one more Indian wheat (Punjab 8-A) were taken up and sowings were made at Delhi and Simla, as before. Results of the year under report were confirmatory and showed that Indian wheats respond only to light treatment given after sowing, there

being very little or no effect of pre-sowing temperature treatment. Two English spring wheats, April Bearded and Red Marvel have, unlike winter wheats, responded to temperature and light treatments separately. In this respect, the behaviour of English spring wheats was similar to that of gram. Results of light treatment after sowing were in agreement with those of last year.

The F_1 plants of a cross between the English winter wheat Yeoman II and the Indian wheat I. P. 114 flowered earlier under long days even without chilling of seeds, thereby showing that the habit of the Indian wheat was dominant.

Gram.—Vernalized seeds along with controls were sown in September, October and November. The maximum earliness obtained in I. P. 9 was as much as 116 days (approximately). Results of light experiments confirmed the previous year's finding that gram responds to temperature and light individually.

Linseed.—Two varieties, I. P. 12 and I. P. Hy. 68 were given temperature treatment and an earliness of about one week was obtained in both.

Other crops.—Experiments are in progress on tobacco, potato, tomato and jowar, the last two crops having been taken up in 1940.

Vernalization of seeds at different stages of germination.—Mustard, wheat and gram were used for these experiments. Plants from sprouted vernalized seeds flowered earlier than those from unsprouted seeds by seven days in mustard and by twelve days in gram. Unsprouted seeds took longer to get vernalized than sprouted ones. In wheat, sprouted vernalized seeds of Cambridge Rivett flowered 7 days earlier than untreated controls. Indian wheats showed no response to temperature treatment either in the sprouted or in the unsprouted condition.

Attempts are being made to see if seed can be dried after vernalization, without losing the effect of the pre-sowing treatment.

The effect of short day conditions (9 hours daylight) on 14 species of potato was studied at Simla. The results indicated a general depressing effect on flowering, a significant increase in yield except in a few species and a considerable reduction in the growth period.

A note on vernalization was submitted to the Board of Agriculture at its meeting held in December 1939.

4. STUDIES IN VARIABILITY OF CROP PLANTS

Wheat.—The study of variability in the Afghanistan collection of wheats was continued and detailed notes were taken on the 470 cultures. New material collected by the Agricultural Delegation which visited Afghanistan in 1939 was also under study. In general the cultures were late-maturing and weak-strawed, and many of them showed high susceptibility to rust. In a preliminary yield trial conducted at Delhi, two cultures significantly outyielded I. P. 165 which was used as the standard.

Potatoes.—Detailed morphological and physiological notes on 26 *desi* European varieties obtained after elimination of duplicates from a collection of 294 samples from all over India were recorded. The identification received from Dr. R. N. Salaman, Chairman, Potato Synonym Committee of the National Institute of Agricultural Botany, Cambridge, showed that most of the Indian varieties belong to old European varieties which today have become unidentifiable.

One hundred and forty one cultures derived from 118 samples of Indian commercial varieties received through the Marketing Officer to the Government of India have been studied with a view to clearing up the question of what botanical varieties are represented under the common trade names. The varieties have been divided into three groups, *viz.*, *desi* varieties representing five distinct types made up of 71 samples; European varieties including 54 samples belonging to eleven named varieties, and unknown varieties consisting of 16 samples representing old European and American varieties. These results show that although about 30 distinct varieties are grown in India only about 8 are important from the point of view of trade.

The study of the South American material consisting of Chilean *tuberosums*, other wild and cultivated species and their hybrids was also continued.

Linseed.—The varieties obtained from Argentine and Afghanistan were grown but were found to be too late for conditions obtaining at Delhi. The *Linum perenne* collections failed to set seed owing to their late maturity.

Pigeon-pea.—The twelve exotic strains received from Hawaii were again grown with I. P. selections and found to be inferior in growth and yield as compared to the latter. Many of them were also impure for seed and pod characters.

Seed of various crop plants received from the Agricultural Delegation to Afghanistan was also grown and studied.

5. MISCELLANEOUS

YIELD TRIALS

Wheat.—Results from the third year of the co-operative yield trials have been received and are being analysed for comparison with those of the previous years.

Potato.—A yield trial was carried out with eight varieties. The order of merit as regards yields was Pusa White (= Phulwa), Rogue No. 238, Darjeeling Red, Great Scot, Numbri (Up-to-date), Kangra local, Imperia and Gola.

Another experiment to find out the best time for planting potatoes at Delhi showed that for the Pusa White variety the earlier plantings were the most successful, the first planting (middle of September) resulting in the highest yield.

Other crops.—Varietal trials with barley, oats, rice, etc., were carried out at Pusa and the results are given in the report of the Botanical Sub-station.

COOKING TESTS

Cooking tests made with 10 varieties of potatoes showed that culture Nos. 11 and 316 were of very good cooking quality, whereas culture No. 256 was definitely poor.

GRAM WILT

Gram types I. P. 25, I. P. 53 and I. P. 58 were grown after fallow and after sorghum in replicated plots in a field in which there was a heavy incidence of gram wilt the previous year to see if there is any truth in the belief that gram suffers less from wilt when grown after sorghum than after fallow. Unfortunately the disease was practically absent this year and no definite results could be obtained. The experiment will be repeated.

TOBACCO LEAF-CURL DISEASE.

Investigations conducted at Pusa on the lines of previous years have again confirmed the results already obtained.

SEED-SETTING IN BERSEEM (*Trifolium* spp.)

With a view to studying the technical difficulties of seed setting in berseem, a preliminary experiment was in progress at Delhi and Pusa. Ten varieties belonging to four different species of *Trifolium* were sown on three different dates and studied with regard to seed setting under conditions of open pollination and selfing. A few crosses were also made. A record of the environmental conditions, like temperature and humidity percentage, prevailing at the time of flowering of the varieties in the two localities was also maintained for finding out any correlation between seed setting and environmental conditions. Suitable selections have been made and the study will be continued.

FLORAL BIOLOGY AND ANTHESIS IN BRINJAL (*Solanum Melongena* L.)

As a preliminary to the investigation of hybrid vigour in the brinjal, the biology of the flower was studied in a large number of varieties obtained from various sources. The results show that this plant is self-fertile but not self-pollinated; in nature pollination is done by insect visitors. No incompatibility between the different varieties was observed. Flowers in which the stigma reaches at least up to the middle of the anther cone form fruits if pollinated at the proper time; but in short-styled flowers no fruits are formed even with hand pollination. Anthesis is greatly influenced by the prevailing temperature and humidity.

III. CROP OUTTURNS AND SEED DISTRIBUTION

Although on the whole the yields are lower than those of last year, they were still extremely satisfactory. The quality of the produce was excellent

In the case of wheat high bushel weights were obtained. The crop outturns are given in the statement below :—

Statement showing the yields of crops in Botanical Area at New Delhi in 1939-40.

Crop	Variety	Plot No	Area in acres	Outturn			
				Actual		Per acre	
				Mds	Lbs	Mds	Lbs
Wheat . . .	I. P. 4 . . .	23	1.0	31.57	2598.2	31.57	2598.2
	I. P. 12 . . .	24	1.0	32.17	2647.5	32.17	2647.5
	I. P. 52 . . .	20	0.5	12.22	1005.9	24.45	2011.9
	I. P. 80-5 . . .	14	1.0	30.62	2502.0	30.62	2502.0
	I. P. 111 . . .	21	1.0	31.75	2612.6	31.75	2612.6
	I. P. 114 . . .	6	0.5	15.50	1275.4	31.00	2550.9
	I. P. 120 . . .	6	0.5	16.42	1351.5	32.85	2703.0
	I. P. 125 . . .	20	0.5	12.10	995.7	24.20	1991.3
	I. P. 165 . . .	12	1.0	27.12	2232.0	27.12	2232.0
Barley . . .	I. P. 13 . . .	26	0.83	37.57	3091.9	45.07	3709.1
Oats . . .	I. P. 1 . . .	22	0.5	19.77	1627.2	39.55	3254.4
	I. P. 2 . . .	22	0.5	19.40	1596.3	38.80	3192.6
	I. P. Hyb. 1 . . .	25	0.5	18.52	1524.3	37.05	3048.6
	I. P. Hyb. 3 . . .	25	0.5	14.65	1205.5	29.30	2411.0
Gram . . .	I. P. 17 . . .	49	0.8	15.47	1273.4	19.32	1590.2
	I. P. 25 . . .	32	1.3	11.35	933.9	8.72	717.9
	I. P. 25 . . .	33	0.17	4.42	364.1	26.02	2145.5
	I. P. 25 . . .	34	0.65	8.75	720.0	13.45	1106.7
	I. P. 25 . . .	35	0.84	15.22	1252.8	18.12	1491.4
	I. P. 25 . . .	36	1.0	17.5	1468.8	17.85	1468.8
	I. P. 25 . . .	37	1.0	17.60	1448.2	17.60	1448.2
	I. P. 53 . . .	27	1.0	9.40	773.5	9.40	773.5
	I. P. 58 . . .	15	0.5	3.90	320.9	7.80	641.8
	I. P. 58 . . .	16	1.0	9.47	779.7	9.47	779.7
Peas . . .	I. P. 29 . . .	28	0.97	31.77	2614.7	32.75	2694.8
	I. P. 29 . . .	30	0.48	20.92	1721.8	43.57	3585.6
	I. P. 29 . . .	48	0.44	6.02	495.8	13.67	1125.3
Lentil . . .	I. P. Hyb. 1 . . .	4	0.83	5.50	452.6	6.60	543.1

Seeds were supplied by the Section and the Botanical Substation, Pusa to the Agricultural Section for multiplication and also to a large number of

agricultural officers and private individuals in India and abroad. The quantities of seeds distributed by the Section are shown below :—

Statement showing the quantities of pure seeds distributed during the year 1939-40

Variety	Quantity in lb
Barley—	
I. P. 13	4114·3
Chilli—	
I. P. 34	2·7
I. P. 41	·5
I. P. 46	0·6
I. P. 51	1·4
Gram—	
I. P. 25	2041·1
I. P. 53	74·1
I. P. 58	1184·9
Lentil—	
I. P. Hyb. 1	51·4
Oats—	
I. P. 1	1326·9
I. P. 2	1800·0
I. P. Hyb. 1	1377·13
I. P. Hyb. 3	1795·9
Hibiscus—	
I. P. 3	2·1
Peas—	
I. P. 29	2019·12
Rahar—	
I. P. 5	3·6
Safflower—	
I. P. 1	0·1
I. P. 24	0·1
I. P. 27	0·1
Wheat—	
I. P. 4	2875·9
I. P. 12	2988·10
I. P. 52	268·15
I. P. 80-5	166·7
I. P. 101	30·9
I. P. 111	526·0
I. P. 114	834·12
I. P. 120	693·3
I. P. 125	2856·14
I. P. 165	2890·3

IV. PROGRAMME OF WORK FOR 1940-41

- (i) Continuation of the breeding work paying special attention to disease resistance.
- (ii) Continuation of the genetical and cytological studies mentioned in this report.
- (iii) Continuation of the special studies on vernalization and hybrid vigour.
- (iv) Investigation of the factors influencing seed-setting in berseem.
- (v) Continuation of varietal studies and maintenance of crop collections.

REPORT OF THE SUGARCANE EXPERT

(T. S. VENKATRAMAN)

I. INTRODUCTION

This report embodies work on breeding carried out at the Sugarcane Station of the Imperial Agricultural Research Institute, New Delhi, and located at Coimbatore in South India. During the year there were two schemes in progress at the station financed by the Imperial Council of Agricultural Research, viz., (1) Scheme for Research on the Genetics of Sugarcane and (2) the Sugarcane Substation, Karnal. Salient features of the latter are included in this report; little work was recorded in the former on account of the post of Sugarcane Geneticist being vacant practically all through the year.

II. SUGARCANE BREEDING

Specialization.—The aims of breeding at the station are getting increasingly specialised. Besides the breeding of 'early' and 'late' canes, their reaction to pests and diseases is receiving increasing attention in the selection of parents for crossing. Anatomical work on the wild *Saccharums* and *Saccharum* × *Sorghum* hybrids (financed by the Imperial Council of Agricultural Research) has yielded certain useful findings. *S. spontaneum* employed as male parent is found to definitely transmit rind hardness to the hybrids which in certain cases has proved to be greater than that in *S. spontaneum* itself. Such studies are being extended by various means to fully explore correlations between anatomical features and resistance to pests and diseases.

Programme of hybridization.—At this stage it is perhaps worthwhile recording the gains to sugarcane breeding from the various lines of hybridization effected at the station, both interspecific and intergeneric.

The breeding of economic types has distinctly gained from the inclusion of *S. spontaneum*—both the Indian and the Javanese types—in the parentage. The advantage has largely been in the direction of greater growth vigour and greater resistance to pests, diseases and adverse conditions. There has been a slight adverse effect on juice quality but more than fully compensated for by increased tonnages. The intergeneric *Sorghum Durra* crosses have yielded very few economic types, but a few parents of proven utility have resulted. The *Sorghum halapense* crosses as well as the *Narenga* crosses have not yet led to any economic results, the latter because of infertility of hybrids. The *Sorghum halapense* crosses might prove useful in the breeding of fodder types. The bamboo hybrids are too recent but so far this parent does not appear to have introduced any appreciable resistance to pests and diseases; their juice qualities have generally been such as to need further hybridisation for useful results.

The number of popular Coimbatore canes are now so numerous and their performance in various parts of India so well known that they are playing a

steadily increasing role as parents at the station. The demarcation line between the so called 'medium' and 'thick or noble' types is getting fainter. This is because of the wider range of climatic and soil conditions which the new productions are able to tolerate as the direct result of the range and nicety with which the parents are selected for crossing.

III. INVESTIGATIONS

Pollen studies.—Some advance was recorded in the preservation of sugarcane pollen by the employment of Thermos Flask with a suitable arrangement for controlling the temperature and humidity inside the flask. Sugarcane varieties showed differences in period of viability of their pollen ranging from 20 days with *S. spontaneum* to about 14 days with some of the 'noble' types.

The non-availability of bagging for large scale breeding work in the sugarcane necessitated an evaluation of the amount of air laden sugarcane pollen in the cane plots during different parts of the day, at different ground levels and under different conditions of humidity and wind velocity. The atmosphere was found comparatively free from cane pollen for the fairly long period of from 10 A.M. to about 5 A.M. the succeeding day. Belt of close growing shrubs like *Thevetia parviflora* proved a fairly effective barrier to pollen movement.

Sugarcane × Bamboo hybrids.—Inheritance studies on Sugarcane × Bamboo hybrids revealed in the hybrids a certain number of anatomical characters definitely attributable to the bamboo parent and sometimes not available within the genus *Saccharum*. The analyses of characters brought out the dominating influence of the *Saccharum* mother parent in these hybrids.

Young stems of bamboo when crushed in the sugarcane mill recorded as much as 5.2 per cent sucrose in juice which is higher than that found in certain of the wild *Saccharums*. Juice analyses of certain of the bamboo hybrids showed obvious influence of the bamboo parent in their starch, inulin and galactin contents.

Vegetative bud sports were recorded in the bamboo after a fairly intensive study of this parent and this establishes yet another link between the two genera so widely separated from each other in their taxonomic position.

Juice studies.—Sugarcane juice freezes into solid blocks at about -3°C . and in this condition no deterioration is noticed for about ten days. Experiments are being continued to ascertain the maximum period with the object of developing methods for analyses of juices from long distances. When such juice is subsequently melted under ordinary atmospheric conditions the earlier fractional meltings showed higher concentration of sucrose than the later ones, the difference being as much as from 11 per cent sucrose in the first melting to only 5 per cent sucrose in the final melting. The purities were, however, practically the same.

**Genetics of the sugarcane.*—There was a break in the scheme of work on the genetics of the sugarcane. The post of Sugarcane Geneticist was vacant during practically the whole year under report. Chromosome work on Co. canes was continued and chromosome numbers recorded for as many as over twenty of the popular types.

IV. SUGARCANE BREEDING (MAINLY TROPICAL TYPES)†

Crosses and seedlings.—The study of the various crosses for breeding the thick type of canes brought out the usefulness of a few new parents. One such is Co. 440 which looks like replacing P. O. J. 2725 for evolving 'early' and 'rich' types. For producing general purpose types Co. 419 and Co. 421 were again employed as female parents in several crosses. They yield vigorous seedlings and the seed germination is good. None of the seedlings of Co. 419, however, was outstanding enough. Co. 421, on the other hand, contributed a few promising seedlings.

In all, forty-two crosses were effected of which three were on a bulk scale and two semi-bulk. The rest were experimental. Among the crosses which deserve mention are Co. 360 × Co. 290 and Co. 361 × Co. 285.

Test plots.—About 400 seedlings were handled in the various Test Plots. In each plot the respective Standard Varieties were grown for comparison. Based on their performance against the standards, six seedling canes were raised to the status of 'Co' canes, viz., Co. 460 to Co. 465. Their parentages are given elsewhere in the report.

Controlling time of flowering.—Certain useful parents like Co. 285 and Co. 421 finish off their flowering in the early part of the season and are not available for crossing with those that come into flower late in the season. Suitable 'Photoperiodism' and 'Topping' experiments were devised to delay the flowering time.

(a) *Photoperiodism.*—Co. 285 and Co. 421 were given extra illumination for one month from 1st July to 1st August. They flowered 17 and 14 days respectively later than the Controls. The 'arrows' were utilized for breeding.

(b) *Topping.*—The tops of Co. 285 and Co. 421 were removed thrice at fortnightly intervals beginning with the last week of July. The treatment was effective in delaying their flowering by 15 and 16 days respectively, but the size of the 'arrow' was found to be much reduced. This did not however, materially affect the fertility of the essential organs, as proved by seed setting in Co. 421 and pollen germinations in Co. 285.

(c) *Colchicine and Acenaphthene.*—A preliminary experiment was tried with the above two chemicals by soaking the setts of Red Mauritius, P. O. J. 2714, and Co. 205 in their solution at the time of planting. The result was that in both the treatments Red Mauritius did not flower either in the treated

*The scheme is financed by the Imperial Council of Agricultural Research.

†This research was carried out under Mr. Nand Lal Dutt, Second Cane Breeding Officer.

or in Control, P. O. J. 2714 flowered only in the Control, and in Co. 205 the percentage of flowering was less in the treated as compared with the Control.

Floral Characteristics.—The studies on floral characteristics have formed a very useful adjunct of the cane breeding technique for thick canes. A new item included in these studies was the observation of the time taken from the formation of the arrow rudiments to the full development of the inflorescence and its emergence from the leaf-sheath.

Stomata.—Observations made on a few varieties indicated differences in the ratio of the number of stomata on the lower surface to that on the upper surface. The *S. officinarum* varieties did not exceed the ratio 2 : 1. The ratio in the local *Spontaneum* was 3 : 2 as against 3 : 1 in Glagah. Creole had the ratio 5 : 2, while in Puri it was 2 : 1.

V. SUGARCANE SUBSTATION, KARNAL*

The large-scale growing of seedlings as seedlings at Karnal yielded useful data in the matter of parents to be employed in breeding for subtropical India ; Co. 312 has proved useful for introducing growth vigour and both Cos. 385 and 313 for introducing ' earliness '. During the season six selections were made under Karnal conditions and were distributed to subtropical stations for further tests. There was a fair amount of smut at the Substation and this resulted in certain useful, though preliminary, indications about the possibility of obtaining healthy planting material from clumps at different stages of smut attack.

VI. RECEIPT AND DESPATCH OF CANES

(a) RECEIPT OF CANES

A type of *S. spontaneum* was received from the U. S. S. R. and another from Mauritius for possible use as parents. Three seedling reported promising in the United States of America were obtained through South Africa.

(b) DISTRIBUTIONS

As canes.—Eleven seedlings were raised to the status of ' Cos ' during the year. Over 175 packets containing the new Cos. as well as other canes specially desired were sent out to various places in India. Fourteen varieties were despatched to foreign countries, viz., Egypt, Sudan, Thailand (Siam), South Africa and United States of America.

As fluff.—Hybrid seeds of desired combinations were sent to the Economic Botanist, Shahjahanpur in the United Provinces, to Risalewala in the Punjab, to the Sugarcane Technologist in Egypt, and to the Director, Agricultural Research Station, Amani, Tanganyika Territory.

*This Substation at Karnal is financed by the Imperial Council of Agricultural Research.

VII.—PERFORMANCE OF COIMBATORE CANES

In India.—Co. 419 often recording maximum yields at Experiment Stations and in plantations, is rapidly becoming the prime favourite in tropical India. It has also proved useful under plantation conditions, in the Sub-tropics. Medium types like Cos. 312, 356, and 313 are continuing their spread in the subtropics where Co. 421 is also steadily making headway.

Foreign countries.—Besides Co. 281 and Co. 290, Co. 301 has also been distributed in South Africa, where these canes are occupying over 56 per cent of the total area. The Coimbatore canes are giving an increased yield of about 40 per cent. over the rapidly disappearing 'Uba'. Co. 290 has filtered even to China from sources other than India.

VIII.—PARENTAGE OF 'CO' SEEDLINGS

The parentage of new 'Co' canes distributed during the year are given below :

Co. 550	} Sc. 851 (P. O. J. 2725 × <i>Sorghum Durra</i>) × Co. 331.
Co. 551	
Co. 552	
Co. 553	
Co. 554	

Co. 460 P. O. J. 2727 × Co. 243

Co. 461 Co. 421 × Co. 419

Co. 462 Co. 421 × Co. 313

Co. 463 Co. 421 × Striped Mauritius

Co. 464 Co. 361 × Co. 285

Co. 465 Co. 440 × Co. 312

IX. PROGRAMME OF WORK

The breeding work will be continued with greater emphasis on specialized lines like resistance to adverse environmental conditions, including pests and diseases.

Cyto-genetic work on parents and 'Co' canes will be continued to further elucidate inheritance of characters.

Investigations on pollen preservation, controlling time of flowering of parents, causes of sterility in canes and the artificial production of polyploids will be continued to try and introduce greater certainty into sugarcane breeding.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST

(B. VISWA NATH)

I. INTRODUCTION

During the year under review Mr. N. V. Joshi retired on superannuation. Mr. Joshi is a pioneer worker in agricultural bacteriology. He is a gifted investigator and made many valuable and enduring contributions to the science of agricultural bacteriology. In his retirement the Section has lost a valuable colleague.

The expansion in the activities of the Section of Soils and Agricultural Chemistry was manifest in the research work as well as in the increasing advisory and analytical work handled during the year. The post-graduate training as well as short course training was imparted to an unusually large number of persons. The policy of having a good reserve of apparatus and chemicals helped a great deal in continuing the work of the Section without handicap due to the shortage of such materials owing to the war.

A number of new investigations were taken up during the year and special investigations on malting of U. P. barleys and grading of fruit syrups and other citrus fruit products were undertaken.

An investigation on sampling errors in a variety of determinations in soils and crops, the evaluation of sampling errors in different methods of bacteriological analyses, spectroscopic analyses of soils and crops for trace elements, and microbiological studies on soils and crops in relation to soil fertility were started.

II. RESEARCH AND INVESTIGATIONS

1. SOILS

Soil and crop maps.—Work on the preparation of soil and crop maps was continued. The soil maps of India, one in relation to soil type and another in relation to climate, giving basic information for different types of soils and the effect of a type of climate on different types of soil were prepared. All available published and unpublished data were systematized and a preliminary map recording the major soil types in relation to geological distribution and colour classification was prepared. Another map on the basis that the soil, irrespective of geological origin, is the expression of bio-climatic and agro-biological influences on the soil, was in course of preparation. Further the maps of climate-cum-soil-cum-crop were being prepared showing the zonal classification of crops as a check on the zonal classification of soils and their bioclimatic character. This is the basis on which the farming, cultural practices and the type of products best adopted to it, have developed. This mapping is important in bringing together the dominant factors of soils under one co-ordinated system of major and minor groups of soils. To distinguish crop adaptation and development in relation to soil

type and climate is of fundamental importance in rational crop planning and economical agriculture.

Soil investigations.—The soil, apart from its geological origin, is under the influence of major and minor effects of the phenomena of life in the soil, climate and seasons relative to the geographic co-ordinants measured and expressed in units of time, temperature and distance. The soil is, therefore, the expression of the geo-biological, bio-climatic and agro-biological forces which are jointly operating; and a study of soils on this basis is particularly suitable to Indian conditions. Climate being the dominant factor in the soil formation processes, the relationship between climate, expressed as N. S. Q., and soil processes on the one hand, and the relationship between soil properties and soil formation processes on the other, have been under study. These studies have helped in arriving at a system of classification into broad zones applicable both to soils and to crops grown on them. In the application of the principles involved in this bio-climatic system of zonal types, the object is to determine the characteristics of the soils and their profiles with reference to a zone and to the transition changes, if any, from one zone to another under the influence of the factors operating in those zones and if possible and necessary to utilize variations, if any, as a basis for interpreting in a broad manner the response of climatic types to different geo-biological and agro-biological conditions that obtain in that zone.

In the reports for the previous two years, discussions were made on the basis of analyses of clays from surface soils and on the number of samples analysed till then. The views then advanced are now corroborated by the results of study, during the year, of the clays separated from other depths to five feet of soils. On a further study of the data for soil properties, it has been found that the inclusion of calcareous soils in certain types (arid and humid) show appreciable deviations from the expected values for the different constituents of the clays. These have, therefore, to be considered as calcareous, a type separate from the four main climatic types, but occurring within the major types.

The degree of resemblance in the chemical composition of clays from the different types of soils, as shown by the silica-sesquioxide ratios, indicates that the accumulation of clay colloids in the lower depths occurs primarily by their movement as such, and that the soil-forming process is influenced chiefly by the intensity of bio-chemical processes in the surface soil under the influence of climate. In the arid type, a progressive increase in $\text{SiO}_2/\text{R}_2\text{O}_3$ values occurs to a depth of four feet and then a decrease reaching near about the value for the first foot of surface soil is noticeable. In the semi-arid type of soils, the progressive decrease is noticed generally up to the third foot, followed by a sudden increase in the fourth foot-layer, due to the separation of lime as carbonate and consequent lowering in the values for alumina and iron oxide. For soils of the humid type, the silica-sesquioxide ratios decrease down to second foot layer and afterwards the ratios increase with depth.

In the per-humid type on the other hand, the values increase even in the second depth, and then register a gradual fall with depth.

In the arid and semi-arid types, most of the iron appears to be in combination with the colloid complex, whereas in the humid and per-humid types, a portion of the iron appears to be present as a silicate complex, while a part occurs as either free or hydrated oxide, as characterised by the silica-alumina ratios. This ratio attains a maximum value in the semi-arid type of soil, due probably to greater solubilisation of silica and formation of the complex, while in the other types silica leaves and alumina accumulates in the colloidal complex.

Base content is highest in the arid types and is progressively lowered through semi-arid, humid and per-humid types. The values for potash are high in all the soil types, due probably to the presence of weathered feldspathic residues. Soils of the semi-arid region show high pH values, followed in decreasing order by arid, humid and per-humid types. This means that hydrolysis is inappreciable in arid, moderate in humid and intense in per-humid types. Soils of the humid region are almost neutral in reaction, while soils of the per-humid type show distinct hydrogenation as the result of intense hydrolysis. The exchange capacity is almost equal to the value for total exchangeable bases in both arid and semi-arid types, while varying degrees of unsaturation are noticed in humid and per-humid types owing to the entry of hydrogen ions into the clay complex.

The soils have been classified into groups on the basis of colour and climate. In addition, calcareous soils which are grey in colour and which belong to both arid and humid regions are placed in a separate group owing to their abnormal content of calcium carbonate and the consequent behaviour in their chemical and physical characteristics.

On the climatic basis, the total base-exchange capacity per 100 gms. of soil does not show much variation from depth to depth in different groups, whereas the same capacity per 100 gms. of clay, assuming that the exchange capacity resides mainly in the clay complex of a soil, shows considerable variation with depth.

Semi-arid and humid soils possess the highest clay contents as well as the greatest base-exchange properties, whereas arid, per-humid and calcareous soils the least of these characteristics. The latter have however no consistent relationship between themselves. The range for the base-exchange capacity of mineral colloids is usually taken to be 0.5 to 1.0 milliequivalent per gram of the colloid, and the results obtained fall within these limits in all the type soils examined.

The percentages of the different exchangeable bases, taking the average value for all the depths in a type and expressed in terms of total exchange capacity in different soil types, are different.

The bases exist in different soil types in the descending order of Ca, Mg, Na, and K. Per-humid soils, as would be expected, have always the least

exchangeable Ca and other bases. The rest of the soil types are either neutral or alkaline in character and possess higher amounts of exchangeable bases. Ca predominates in all the types of soil and constitutes 65 to 82 per cent of total exchangeable bases in alkaline and 28 to 45 per cent in acid soils. Mg constitutes 11 to 23 per cent and 13 per cent respectively in alkaline and acid soils, Na 5 to 19 per cent and 5 to 11 per cent, and K 2 to 5 per cent and 3 to 5 per cent respectively in these soils. Arid soils have about 65 per cent of m. e. exchangeable Ca; semi-arid soils 67 per cent. exchangeable Ca and humid soils 73 per cent. exchangeable Ca, the highest of all the groups of soils. The content of exchangeable Mg comes next in order with similar variation. Arid soils contain the highest of exchangeable Na, *e.g.*, about 20 per cent; semi-arid soils from 9 to 11 per cent and the rest of the soils have 6 per cent of exchangeable Na in terms of total exchange capacity. Of exchangeable K, semi-arid soils contain the least, *e.g.*, about 2 per cent and the rest of the soils from 3 to 5 per cent only.

Some relation, though not very consistent, exists between reaction and exchangeable Ca or total exchange capacity of soils, from the average values for the surface soils only. Where the reaction is acid, having pH below 7, there is a relationship between pH and exchangeable Ca or total exchange capacity of the soils of different groups. Similar relationship holds for the alkaline groups of soil too with the exception of the soils of semi-arid region. With the rise of pH there is a general rise in the values of exchangeable Ca or total exchange capacity of soils.

Further to the work reported last year, soil profiles from Hagari, Nandyal, Samalkot, Anakapalle, Berhampore (Ganjam), Pusa and Delhi were examined for their water-soluble salts. They fall into three out of the five groups into which the other soil profiles were classified previously with regard to the water soluble salts. Hagari and Samalkot come under group III. Sodium is the preponderating base in them. Nandyal belongs to group IV (*a*). Sodium bicarbonate is the principal salt in it. Anakapalle and Berhampore can be classed under group IV (*a*), but their composition bears resemblance to that of group V. They are rich in calcium bicarbonate and sodium chloride. Pusa and Delhi come under group V. The peculiarity with Pusa soil is that it contains nitrate, whereas other profiles of the same group do not. The principal salt in them is calcium bicarbonate.

Soil tillage.—Some more data on soil tillage in relation to type of soil, climate and crop have been collected and the results will soon be available for publication. Experiments have been laid down to test the draught on bullock-drawn implements in relation to soil factors.

Soil Nitrogen.—(*a*) *The nitrification.*—It was reported previously that certain soils in a strip of country running east to west across the middle of India and which includes practically all soil types showed defective nitrification in the laboratory. Further investigation during the year with Omeliansky's solution showed that the soils contained nitrifying organisms.

Although this indicated that under optimum conditions and in the presence of calcium carbonate nitrification could come to normal, addition of calcium carbonate to the soil did not show improvement. The next step was to test the aqueous extracts of the soils and the residual soils after extraction with water. The aqueous extracts after correcting for acidity were sub-normal in regard to nitrification but the extracted soils still showed no improvement.

(b) *Nitrogen fixation by maize.*—The work previously reported was continued and from the data obtained from a large number of experiments it has been concluded that the fixation of nitrogen by the maize plant is twofold—one by the plant itself and the other in the soil by the soil organisms which are stimulated by the root secretions in presence of energy-supplying materials like crop residues and organic manures. The results obtained so far have been written up by Mr. Vyas as a thesis for the M. Sc. (Agri.), degree of the Nagpur University.

(c) *Nitrogen fixation in soil by non-biological agencies.*—Further work on this subject, besides confirming the previous results, has provided evidence that the nitrogen and carbon cycles are not independent of each other, as has been supposed till now, but that each in its progress helps the other, so much so that a knowledge of the status of either carbon or nitrogen and its theoretically calculated oxidation-reduction potential helps to locate the position of the other. The results that are now available throw light on the significance of the nitrogen and carbon losses from the soil and the conditions under which they can be made more stable and losses can be controlled.

Lysimeter studies on soils and crops.—The lysimeter (drain gauge) data maintained at Pusa for over twenty years were collected and consolidated by Mr. A. Sen as part of his thesis. Apart from giving useful information on the ratio of rainfall to percolation, composition of drainage and loss of nitrogen in drainage waters, under cropped and uncropped conditions, the most interesting information is that wheat following sann-hemp is not benefited in yield, although the grain contained a higher nitrogen content. Another interesting point is that although wheat was grown continuously for a number of years without manure but with fallow in the monsoon period, there is no decrease in the yield of wheat while sann-hemp showed marked tendency to decrease in yield.

Mr. A. Sen also investigated the question of lime economy in Indian soils. Seeing that soluble calcium comes from the soil and calcium carbonate, twenty soil profiles were investigated to study the effect of calcium carbonate on soluble calcium or total soluble salts. The data obtained indicated that while it was to be expected that in calcareous soils the soluble salts would be rich in lime under a given rainfall, the same amount of rainfall generated much more soluble salt in non-calcareous soils than in calcareous soils, and that the distribution of soluble salts in a profile of calcareous soil is much more uniform than in non-calcareous soils. The

bearing of this on the estimation of exchangeable calcium was also examined. Soils are extracted with normal sodium chloride for exchangeable calcium. Had it been an ordinary solubility phenomenon a definite correction factor could be used. But all soils do not appear to behave in this manner.

Soil microbiology—(a) The significant role that must be accorded to the micro-organic life in the soil is fully recognised, yet we are far from understanding clearly the relationships of species in the soil, much less their relationship to soil fertility and crop growth. The determination of the numbers of micro-organisms in a soil has only a very limited diagnostic value, and it is necessary to know their physiological activities as well. Before the move of the Institute to Delhi some work was in progress but that was interrupted by the move to Delhi. The work was resumed during the year and extended to include the effect of manurial and fertilizer treatment and crop rotations on the micro-biological population in the soil. The plots selected for the study are the permanent manurial plots at Pusa where the plots under various treatments for several years reached a stable equilibrium.

(b) Following the investigations of Mr. Sundara Rao for his thesis on nitrifying organisms, investigations to determine whether nitrifying organisms are autotrophic or heterotrophic were in progress. Starting with Joshi's intense nitrifying bed facilitated the obtaining of suitable ratio of nitrite-forming organisms to non-nitrifiers, as otherwise the work would have been very difficult. Silicic acid gel was found preferable to ammonium sulphate agar as the former gave clear colonies in 4 to 7 days. Transfers of single colonies from solid to solid medium and then to liquid medium gave pure colonies of nitrifying organisms more quickly than by the method of transferring from a solid to liquid medium alternately. The organisms obtained were all morphologically similar and did not grow either in peptone broth or nutrient agar thus satisfying the test of purity suggested by Winogradsky for autotrophic organisms, although this does not exclude the possibility of the existence of heterotrophic nitrifying organisms.

2. MANURES, FERTILISERS AND PLANT NUTRITION

Decomposition of organic waste materials by anaerobic fermentation.—As against aerobic process of fermentation the process of anaerobic fermentation does exist and though on large scale operation its usefulness is fully utilized, its application to the farm wastes are still not seriously considered.

Experiments were started to find out, in the first instance, how much fuel gas could be obtained in a short time from such farm wastes as straws, dry leaves, dry sludge, farm litter, celluloses, etc. At first bacterial seed-beds were established in two litre bottles by incorporating lake mud with 500 gms. straw powder, 0.5 gm. ammonium sulphate and 5 gm. CaCO_3 . The bacterial seed-bed took some time in getting efficiently going. A month to six weeks elapsed in which further addition of straw was made from time to time without introducing any oxygen. The process which started slowly at first became quite quick, the major portion of the material added being

decomposed and evolved as gas in five days time. The temperature at which the evolution took place rapidly was in the neighbourhood of 38°C. Lower temperatures decreased the efficiency, while higher temperatures upto 48°-50° C did not materially increase it.

The gas evolved was analysed for its composition and calorific value to find how it was affected by the composition of the materials employed. The composition of the gases was almost similar in each case. As calculated from the evolution of gas 85 per cent. of the carbon content of materials like straw were converted into the gaseous form by this type of fermentation.

All the nitrogen of the fermented material was conserved in the bacterial seed-bed and after a time no addition of nitrogenous material like ammonium sulphate was necessary. The nitrogenous materials are necessary only in the beginning to set up the bacterial bed, later on any material added goes on to increase the nitrogen content of the fermented material. Part of the fermented materials were occasionally taken out and dried. These dry easily and are without any obnoxious smell and contain a fair percentage of nitrogen in an easily nitrifiable state.

Manurial and environmental factors on the composition of the crop.—The work during the year on the effect of manurial treatment on the composition of wheat grain (I. P. 52) included the determinations of proteins, ash, phosphorus and calcium of wheats grown under different manurial treatments. The differences in the above constituents in the farmyard-manure-grown and mineral-manure-grown wheats was not appreciable, but green-manured wheat appeared to increase very greatly in all the protein fractions except glutenin.

Investigations were also made on eight I. P. wheat types grown under widely different environments, *i.e.* grown at Pusa, Delhi and Karnal in the same year. While varietal differences are no doubt quite considerable, equally wide differences appear to be induced by environment. The evidence points to considerable changes in the protein complex of wheats under different environments. This is bound to have an effect on the nutritive values of the wheats.

Varietal differences in plant nutrition.—Further data were obtained on varietal differences in plant nutrition. In the course of investigations on sugarcane with reference to juice qualities, data have been obtained on the differential absorption of calcium and phosphorus by different varieties and for the same variety in different places. The results available so far show, that while some canes absorb calcium and phosphorus in the ratio of 1:1 others absorb in ratios of 1 : 2 and more.

Investigations on eight I. P. types of wheat showed considerable variations both in their ultimate and proximate constituents.

Sugarcane mosaic.—The search for the bacterial cyclostage in the life-cycle of sugarcane mosaic was continued, and monthly observations on the appearance of bacterial growth were made in the mosaic and healthy juice

filtrates beginning from March to the end of September 1939. Bacterial growths appeared as usual in the mosaic leaf filtrates upto the middle of June, and after that no growths appeared in any of the filtrates. This confirmed the previous finding that bacterial growths appear in the mosaic leaf filtrates during certain months of the year, *i.e.*, from March to the middle of June. Attempts at finding out bacterial growth in the filtrates of sugarcane leaves inoculated with sugarcane mosaic did not succeed. The mosaic did not establish itself fully in the plant as very few leaves showed mosaic symptoms.

III. INVESTIGATIONS ON AGRICULTURAL PRODUCTS

(1) SUGARCANE AND GUR INVESTIGATIONS

¹ Work was continued on the chemistry of sugarcane and *gur* (jaggery) to ascertain the nature of constituents responsible for the colour, structure and keeping quality of *gur*. This necessitated a study of the methods of estimating reducing sugars and other non-sugar constituents. A technique for dividing the non-sugars present in cane juices and jaggeries into three broad categories on the basis of their differential solubility in different reagents was developed. The data are expected to give information on the role of non-sugars as well as their fluctuations from period to period and from variety to variety and on the influence of soil and climatic conditions.

It would appear from the data so far available that more than the ash content of juices, the ratio of organic non-sugars to sucrose in the juice influence the clarification and type of the jaggery product and that a ratio of 9 and above in the juice is an index of its quality for carbon clarification. How far this will be corroborated by further data remains to be seen.

Active carbon.—Mr. P. B. Sanyal continued to guide throughout the year the work on active carbon manufacture and gur production by the active carbon process. The investigations cover the large scale economic production of active carbon and its use in the manufacture of gur. The results, which are expected to be published by the United Provinces authorities, are of very great significance in advancing the use of the active carbon process of *gur* manufacture as an economic proposition.

(2) INVESTIGATION INTO THE MALTING QUALITIES OF U. P. BARLEYS

At the instance of the Agricultural Marketing Adviser to the Government of India and in co-operation with the Economic Botanist, U. P. Department of Agriculture, malting tests on U. P. barleys were carried out exactly on the same lines as those followed at the Institute of Brewing in London. 117 samples of barleys were received from the Economic Botanist, U. P.

From the performance of a single variety of C. 251 barley, grown in different districts, that in that season the same type of barley produced malts of widely varying quality. The number of samples was small and there were gaps of districts from which samples were not available. It is, therefore, not valid to correlate soil and climatic factors with malting values, but the

data strongly suggest that certain districts produced barleys of better malting quality than others. Generally, the barley samples were of high quality and malted well. The average for all the samples of the 1938-39 crop was 100.2 brewer's lb. per standard quarter calculated on dry basis. Besides the question of performance at different places of C. 251 variety, the investigation also provides answer as to how different varieties fared at one place. The chief consideration here is the varietal factor consistent with high extract, and on this basis J. 63 and A. 50 were as good as C. 251 at some of the very best localities in U. P.

(3) PRODUCTION OF MUCILAGE FROM SUGARCANE JUICE BY BACTERIAL ACTION

The problem was investigated when contamination of the sugarcane juice produced a thick mucilaginous liquid. The bacteria were isolated and they were able to produce the gum by artificial incubation. The temperature most favourable for the process was near about 20° C. Various preservatives were tried to ensure the keeping quality of the mucilage produced. Sodium benzoate was found to be most effective. One drawback of the mucilage produced was that the drying up of the mucilaginous films took some time. Addition of alum and aluminum sulphate increased the rate of drying. The organisms were identified as *Leuconostoc Mesenteroides* and the biochemical reaction studied.

(4) INVESTIGATIONS ON GHEE

Miss B. N. Katrack, an honorary research worker, investigated the thiocyanogen values of fats with special reference to *ghee* containing known amounts of foreign fats. This value, when taken in conjunction with the iodine value, can be used to determine the distribution of the unsaturated fatty acids in a fat. This principle has been used in an attempt to detect the addition of foreign fats to butter fat. While the iodine value gives a value for the total unsaturation of a fat, the thiocyanogen value measures the whole unsaturation of oleic, half the unsaturation of linoleic and two-thirds of the unsaturation of linolenic acid. The iodine and thiocyanogen values for some common vegetable oils, *vanaspati* and genuine *ghee* were determined using Hubl's method for iodine and Kaufman's method and technique for thiocyanogen values. Then the values for *ghee* containing 10, 20, 30, etc. per cent of the oils or *vanaspati* were also determined. It was found that values for the mixed fats obeyed a simple mixture law; that is, one fat did not have any effect on the respective unsaturation values of another when mixed with it.

Considering the fairly wide range of unsaturation of fatty acids of butter fat and oils, this method will not throw much light on the adulteration of genuine *ghee* with foreign fats, especially the *vanaspatis*. The calculated values of unsaturated glycerides may be more valuable for this purpose, but even here the method fails to detect adulteration of genuine *ghee* by 10 per cent of foreign fats.

Work on fluorescence methods :—When oils and melted fats are exposed to ultraviolet light, they fluoresce to different degrees and with different colours. When exposed to the rays of mercury vapour lamp vegetable oils give a blue and butter fats give a greenish—yellow fluorescence. The adulteration of *ghee* with 10 per cent of vegetable oil gives a blue fluorescence which is paler than that of the pure vegetable oil. Various oils and fats give the following fluorescences. Coconut oil, arachis oil, niger seed oil and *vanaspati* products, blue ; sesame, violet ; mustard, brown ; lard, grey ; genuine cow's *ghee* greenish yellow ; *ghee* containing 10 per cent coconut oil, pale blue.

Attempts made to characterise these fluorescences by determining the wavelengths of their absorption bands did not give satisfactory results yet.

The wavelengths of the spectra were almost the same for genuine *ghee*, different vegetable oils, *vanaspati*s and mixtures of oils and *ghee*. This shows that the fluorescent spectrum is too feeble to be seen in presence of the absorption spectrum of the light passing through the fats. Experiments by cutting off the visible rays emanating from the mercury arc lamp and getting spectra photographs of the fluorescence obtained from the filtered light will be tried.

IV. ROUTINE AND ADVISORY

The following samples were analysed and reported upon during the year :—

Soils	39
Feeding stuffs	32
Manures	11
Water	5
Potato tubers	63
Citrus fruit products	12
Sludge	16
Pyrethrum flowers	9
Insecticide and fungicide	5
Sugarcane juice	179
Activated charcoal	21
Miscellaneous	22
Wheat samples	27
Barley samples	118
Total	559

A few items of interest may be mentioned.

Soils from saffron-growing districts of Kashmir were sent by the Director of Agriculture, Kashmir. The soils appeared well supplied with common plant food such as lime, phosphoric acid and potash, but were somewhat deficient in nitrogen. The soils are composed of considerable amounts of fine soil particles, having a total of about 69·1 per cent. of silt and clay. The soil reaction is just alkaline and quite favourable for plant growth.

Some soil samples were received from the Andamans where land is being reclaimed. The progress made by the reclamation process was reported upon and suggestions about the reclamation were given.

A number of soils were received from the tobacco-growing area of Guntur. These were analysed and nothing special was noticed.

A large number of samples of various feeding stuffs like oil-cakes, *jowar* stalks, chalk, salt and bran were examined, and their feeding values reported. An interesting item was that a supply alleged to be chalk was found to be that of gypsum and talc, which produced alimentary complaints in the dairy cattle fed with it. In ordinary appearance the talcum powder appeared to be very similar to high grade chalk.

Some samples of *baru* grass and of *bajra* grass silage were examined for the presence of hydrocyanic acid. All of them were found to be free from hydrocyanic acid.

Quality of Pyrethrum grown in India.—At the instance of the Malaria Research Institute comparative analyses were made of nine samples of Pyrethrum, one from Kenya, one from Coonoor, one from Kashmir and six from the North-West Frontier Province. The Kenya variety was reported to have a guaranteed total Pyrethrin content of 1.36 per cent. and this was confirmed by analysis. The samples got were almost opened Pyrethrum flowers except for three samples from the N.-W. F. P. out of which two were buds and one half-opened flowers. The Pyrethrin I and Pyrethrin II content of the samples were determined by Seil's method described in Gonadingei's "Pyrethrum Flowers."

The samples from the N.-W. F. P. are the best of the Indian varieties analysed, with a maximum total Pyrethrin content of 1.11 per cent., and a minimum of 0.89 per cent. for flowers, while flower buds contained 0.61 per cent. The ratio of Pyrethrin I to Pyrethrin II in the opened flowers from both the Indian and Kenya varieties is approximately 1 : 1.

Citrus fruit products.—The grading of the citrus fruit products was undertaken at the instance of the Agricultural Marketing Adviser to the Government of India. All the samples received were analysed and graded according to the standard fixed under the Grading and Marketing Act of 1937.

Sugarcane juice.—A large number of sugarcane juice samples were analysed for the Imperial Agriculturist. On the whole this year's crop had matured earlier than the previous year's. The insect damage was not much.

The purity of juices of most of the varieties was more than 87 per cent. and in some it was as high as 90 per cent. or more. Sucrose content of the juice varied from 16 per cent. to 21 per cent. and invert sugar from 0.06 to 0.47 per cent. Canes of the varieties Co. 331, 419, 431, 433 attained the average weight of 1.5 lb. per cane and yielded juice of more than 90 per cent. purity, 19 per cent. sucrose content and less than 0.1 per cent.

invert sugar. Co. 508 gave a juice having 23·5 brix, 21·09 per cent. sucrose and 0·13 per cent. invert sugar, the purity of juice being 89·68 per cent. Co. 445 and Co. 513 were not promising.

V. PROGRAMME OF WORK—GENERAL

The following is the skeleton programme of work drawn up for the Section for the next few years to be followed as facilities become available.

1. SOILS.

(a) Comparative physical, chemical and microbiological studies on cultivated and uncultivated soils to ascertain the trend of pedogenic processes under the influence of climate and geology and the changes brought about by cultivation and cropping under irrigated and unirrigated conditions.

(b) Collation of data and preparation of a soil map of India.

(c) Nitrogen fixation and carbon and nitrogen cycles in soils.

(d) So far, a considerable amount of attention has been paid to nitrogen whose supplies are available easily and in unlimited quantities by chemical and microbiological methods. The question of soil phosphates, the supplies of which are very limited has not received the attention it deserves. Different forms of phosphorous and its availability in different types of soils, such as alkaline, acid, ferruginous and laterite, will be studied.

2. SOIL IN RELATION TO PLANT

(a) Different methods of cultivation in relation to crop yields.

(b) Draught of bullock drawn implements.

(c) Composition and nutritive value of crops as influenced by soil and fertilizer treatment.

(d) Cereal crops in relation to soil nitrogen.

3. MANURES AND FERTILIZERS

(a) Relative efficiencies of organic manures and mineral fertilizers in relation to moisture availability and soil composition.

(b) Possibilities of increasing the efficiency of fertilizers as judged by recoveries in crops.

(c) Comparative merits of organic and inorganic manures on crop quality for industrial and food purposes.

(d) Varietal differences with regard to fertilizer requirements.

(e) In view of the importance of organic matter to soils, the study of the relative importance of organic matter and nitrogen contained in manures and the factors that contribute to the stability or rapidity of the destruction of the organic matter of the manures.

4. METHODS

(a) Investigation of sampling methods for soils and crops.

(b) Comparative studies on analytical methods employed in soil, crop, fertilizers and food analysis, having regard to reliability, cheapness and rapidity. The relative merits of quick versus slow methods will also be studied.

5. UTILISATION OF AGRICULTURAL PRODUCE AND AGRICULTURAL WASTES

Every agricultural crop grown needs processing either for preservation or for sale and all produce and waste should be considered as potentially valuable material for industry and trade. The study of the scientific and economic questions involved in the utilisation of agricultural produce and agricultural wastes and the development, where possible, of methods within the ability of the farmer will be of considerable advantage to him. Examples of these are the preparation of jaggery or gur from sugarcane and the making of activated carbon from a waste product like paddy husk.

Programme for 1940-41

The major lines of programme for 1940-41 will be :—

1. Comparative studies on soils formed under different conditions of temperature, rainfall and evaporation.
2. Studies on carbon and nitrogen fixation in soils.
3. Investigations on the chemistry of sugarcane and manufacture of gur.
4. Investigations on sampling and analytical methods.

REPORT OF THE IMPERIAL MYCOLOGIST

(G. WATTS PADWICK)

I.—DISEASES OF PLANTS

1. WHEAT

Out of a total number of 90 varieties of wheat tested last year for resistance to loose smut caused by *Ustilago Tritici* (Pers.) Jens., 54 were rejected due to high susceptibility or for other undesirable characters. Of the remainder, 20 showed no infection and the others varying degrees of susceptibility. The collection of loose smut used in these experiments was made at Pusa in 1937. Results with a second collection made at Delhi in 1939 suggest that this may be a different physiologic form. Further collections have now been made from several places in north-west India. Seventy varieties of wheat were tested for resistance to flag smut caused by *Urocystis Tritici* Koern. Twenty-nine of these showed no infection, including all those varieties which showed no infection in previous years.

A foot and root-rot disease of wheat new to India was found causing considerable damage in the neighbourhood of Pusa, Bihar. A fungus closely resembling *Ophiobolus graminis* Sacc. was isolated from several fields. It proved highly destructive in inoculation experiments, the symptoms produced being precisely those caused by the "take-all" fungus, *O. graminis*. No perithecia, however, were found either in nature or in culture and in their absence it cannot be said for certain whether the fungus is *O. graminis* or not.

2. BARLEY

Sulphur dusts, formaldehyde dusts and the commercial product Agrosan G (active ingredients tolylmercuriacetate and ethylmercurichloride) were compared as seed-dressings for control of barley smut caused by *Ustilago Hordei* (Pers.) Lagerh. Unfortunately smut in the untreated control was only 5 per cent., but the disinfectants gave promising results.

3. SUGARCANE

The work on diseases of sugarcane was continued under the special scheme financed by the Imperial Council of Agricultural Research. The full report of the work done is published elsewhere by the Council. Only a brief summary of the main lines of work and the important results obtained is given here.

A severe epidemic of red-rot, caused by *Colletotrichum falcatum* Went. in the United Provinces and Bihar, necessitated concentration on this disease by the Scheme staff. The help of the staff was offered to the Governments of the two provinces concerned. Isolations of the casual organism were made from various localities to determine whether or not

there are different physiological forms of this fungus in India. These included specimens of the mid-rib leaf-spot phase of the disease. In many cases the wilt fungus *Cephalosporium sacchari* Butl. was isolated along with the red-rot organism.

Sugarcane setts of the variety Co. 213 planted in soil to which was added red-rot infected debris developed a severe attack of the disease the controls being uninfected. The fungus was readily reisolated from the diseased shoots. This indicates clearly that infection of healthy setts may take place from the soil. Attempts to obtain the fungus direct from infected soil by the dilution plate method have not, so far, proved successful.

Experiments have been laid out to study the sources of infection with red-rot. The various points at which infection may take place—the cut ends of setts, the root primordia and leaf scars, wounded and intact leaves, etc.,—are being studied. The possibility of dispersal of spores in irrigation water over long distances will be investigated. Experiments have been started to determine how the red-rot and wilt fungi can survive in the soil as cane debris and as mycelium. The possibility of jowar, maize, bajra and elephant grass acting as alternate host for red-rot and wilt organisms is being investigated. Many of these experiments are being duplicated at Coimbatore.

The testing of varieties for resistance to red-rot, smut, wilt and mosaic is continuing and increasing numbers of varieties are being tested each year. The number under test this year is 65 varieties, some of which are intended as parents for crossing.

Experiments to test the mode of infection of canes with smut are being conducted on lines similar to those with red-rot.

In a large-scale demonstration, excellent results were obtained in controlling smut by vigorously roguing out infected clumps. The cane crop grown from setts obtained from plots rogued over a period of two years had only about one fortieth of the original amount of infection. Other methods of control are being tried, including sett treatments. Possible modes of infection with smut are also being investigated.

An experiment on the control of “damping off” of sugarcane seedlings in pans has shown that thick seeding increases the amount of disease, and that it may be reduced by treating the soil with corrosive sublimate.

Seeds of the phanerogamic parasite, *Striga* (growing on cane plants) were sown with cane, sorghum, maize and “bajra” (*Pennisetum typhoideum*). Sorghum and maize became infected, but not “bajra”.

4. GRAM.

Various experiments have been conducted in pots to secure information on the survival of the gram wilt *Rusarium* in soil. The fungus was added to the soil in pots in May 1939. Various soil treatments were given, and in October 1939 gram seeds were sown, the amount of wilt occurring being

taken as an indication of the extent to which the fungus had survived. While the amount or activity of the fungus was reduced during the period from May to October, it was not entirely eliminated under Delhi conditions. The fungus survived well in roots and stems of diseased plants, and even apparently healthy plants growing amongst the diseased ones may harbour sufficient of the fungus to be parasitic on the next season's crop. Application of farm-yard manure seemed to hasten the disappearance of the fungus. A species of *Trichoderma* which was highly antagonistic to the gram wilt fungus in Petri dishes was quite useless in the soil, and a species of *Aspergillus* which retarded infection failed to maintain its good record in the later observations of the experiment.

Fifty-six varieties of gram were tested for resistance to wilt. Of these, only seven had over 30 per cent. infection, namely Imperial Pusa Types 9, 26, 29, 42, 52, 73, and 78. There was a fairly close agreement between results obtained this year and those obtained last year with the nine varieties tested. I. P. Types 9, 28 and 52 were highly susceptible in both years, and I. P. 22, 63, 69 and 83 showed no infection. I. P. 28 was intermediate. I. P. 78 had no infection last year but 32 per cent. this year.

The pyrenidial fungus causing gram wilt, referred to in last year's report was isolated with considerable frequency from both Karnal and Delhi. The description of this fungus, which is a new species, if not a new genus, will shortly be published. Infection can be brought about through soil infestation and by immersing the seed prior to sowing in a spore suspension. It will not, however, attack the foliage when sprayed on the plants. Twenty-five varieties of gram tested for resistance all took infection.

5. LENTILS

A species of *Fusarium* quite distinct from the gram wilt fungus, *F. orthoceras* var. *ciceri*, was isolated from wilted lentil plants at Delhi and Karnal. It was also isolated from certain varieties of gram at Karnal. In inoculation experiments it caused wilt of both lentils and gram, whereas *F. orthoceras* var. *ciceri* infected only gram plants.

6. COTTON, PIGEON-PEA AND SANN-HEMP

An experiment was conducted with the purpose of settling the controversial question of whether the fungi causing wilt of cotton (*Gossypium* sp.), pigeon-pea (*Cajanus cajan*) and sann-hemp (*Crotalaria juncea*) can cross-infect on these hosts. Fifty-one isolates from the three hosts were tested. Although it was found that some of them caused pre-emergence blight of two or even the three hosts, there was a high degree of specificity as regards ability to cause wilt. This work has been submitted for publication.

7. TOBACCO

Attempts were made to bring about the leaf-curl disease in healthy plants by juice transmission. White-flies (*Bemisia gossypiperda*) were fed

on juice extracted from leaf-curl affected plants (D type). For the first time in these investigations, three plants took infection ; ten plants showed distinct symptoms of vein-clearing and some showed vein-banding.

8. LINSEED

Cultures of the rust fungus, *Melampsora lini* (Pers.) Lév., were maintained at Simla for the purpose of testing varieties of linseed for resistance to rust. Linseed plants in Simla were found to be infected with powdery mildew (*Oidium lini* Bondartzew), a new record in India. The attack was so severe that difficulty was experienced in maintaining rust cultures.

9. POTATO

Three important potato problems were investigated during the year, namely, early blight, late blight, and tuber spoilage in storage.

Two hundred and forty-nine varieties or hybrids of potato plants were tested for resistance to early blight caused by *Alternaria solani* (E. and M.) Jones and Grout. Eight varieties only showed complete resistance, but 91 showed only very mild infection. The remainder were more or less severely infected, and in eight varieties the plants were killed.

A species of *Phytophthora* was isolated from leaves and petioles of potato plants reported as suffering from late blight at Simla. Morphological studies made showed that it is not *P. infestans* (Mont.) de By. and more closely resembles *P. parasitica* Dast. It can tolerate high temperatures (33-34°C) at which *P. infestans* cannot grow. Infection tests on tubers and leaves gave positive results and the fungus was reisolated. It is hoped to test varietal resistance to the disease during the next season.

Potato tubers found rotting at the Potato-breeding Sub-station at Simla are being received regularly from the Imperial Economic Botanist, and isolations are being made to determine the casual organisms. The total number of isolates obtained so far is 486, out of which 442 are species of *Fusarium*. Two species of *Fusarium* appear to predominate, one species being represented by 165 isolates and another by 109. Inoculation experiments were made on healthy tubers with sixteen different isolates of *Fusarium*. Four varieties were used, namely "Darjeeling", "Gola", "Great Scott" and "Phulwa". All the isolates infected tubers of the four varieties with varying degrees of success. Two isolates, including a representative of the predominant species, gave 100 per cent. successful infection on all the four varieties.

10. FRUIT AND VEGETABLES

The survey of fruit and vegetable spoilage in Delhi markets which has been going on since November 1937 was completed during the year. Observations made during the year under report confirm in general those recorded in considerable detail last year, and the figures are being collated for the purpose of publication.

II. TAXONOMY

The morphological and cultural study of the *Fusarium* causing wilt of gram, *Cicer arietinum*, and its related species in the sub-section Orthoceras was completed. A number of authentic cultures were obtained from the Centraalbureau voor Schimmelcultures, Baarn, Holland, for the purpose. They were found to vary considerably in their ability to produce pigments, spores in the aerial mycelium, septate spores, chlamydospores, etc. They were found to fall into three groups according to pigment production, one fungus producing a blue or brown pigment, a group producing a purple pigment becoming red in hydrochloric acid and blue or violet in potassium hydroxide, and a non-pigmented group. *F. conglutinans* and its varieties failed to produce pigments, but varieties or forms of *F. orthoceras* fell within all three groups. Pigment production was not appreciably influenced by temperature of growth except with *F. orthoceras* var. *apii* f. 1 Wr., a fungus reported to be non-pigmented, but producing the purple pigment in some cultures at 20° and 25°C.

Production of aerial mycelium and of a so-called stroma, and size of non-septate spores were found to be of no value in identifying these species. The production of pionnotes also seems of doubtful value, since the only culture typically producing them was *F. conglutinans* var. *callistephi*, which is placed by Wollenweber and Reinking in the group with pionnotes typically absent.

Neither the length of conidia nor the number of septations was appreciably affected by temperature, but a high temperature greatly encouraged chlamydospore production. Variation in the asparagine content gave inconclusive results, replicate cultures also showing sharp differences.

The conclusion reached was that *Fusarium conglutinans* Wr. is a synonym of *F. orthoceras* App. et Wr., but it is not proposed to unite *F. orthoceras* with the earlier *F. lini* Bolley for several reasons, or with *F. bostrycoidesi* Wr. et. Rkg. or *F. angustum* Sherb. Thus *F. conglutinans*, *F. conglutinans* var. *betae* Stewart, and *F. conglutinans* var. *callistephi* Beach become varieties of *F. orthoceras*, and the gram wilt fungus is *F. orthoceras* var. *ciceri*.

The *Fusaria* causing wilt of cotton (*Gossypium* sp.), pigeon-pea (*Cajanus cajan*), and sann-hemp (*Crotalaria juncea*) were not found to cross-inoculate readily. By isolating from wilted plants from various parts of India a number of these cultures was obtained, and a comparison was made between them and all the varieties and physiologic forms of *Fusarium vasinfectum* Atk. which were obtained from the Centraalbureau voor Schimmelcultures, Holland, together with a culture of *Fusarium lateritium* Nees var. *uncinatum* Wr. These cultures were grown on two per cent. potato dextrose agar, Brown's agar, Brown's starch agar and steamed rice. It was concluded that the fungi which cause wilt of pigeon-pea and sann-hemp are distinct from *F*

vasinfectum Atk., and recognisable by their tendency to form large numbers of hooked spores in abundant pionnotes, and by their bright orange and yellow colours when grown on steamed rice. It is considered that Butler's reasons for merging *Fusarium udum* Butl. with *F. vasinfectum* Atk. were inadequate. It is further concluded that the wilt organisms of pigeon-pea and sann-hemp are indistinguishable from Wollenweber's so-called "foot-rot" organism (*F. lateritium* var. *uncinatum*). Contrary to the statement by Wollenweber, the number of terminal chlamydospores produced by the latter fungus is insufficient to be disregarded, and the number is masked by the strong tendency of this particular isolate to produce chlamydospores in chains. Furthermore, the evidence of Wollenweber and Reinking in itself suggests the difficulty of placing *F. lateritium* var. *uncinatum* in the section *Lateritium*, and in their key to the species they have been obliged to place this variety in a different section from the fundamental species, *F. lateritium* Nees. It is therefore best to regard *F. lateritium* var. *uncinatum* as a synonym of *F. udum* Butl.

Considerable taxonomic work is being done on the genus *Phytophthora*. As this work is not yet completed a summary cannot be given, but it is interesting to note that a species of *Phytophthora* which caused a form of late blight of potatoes in Simla is *P. parasitica* Dast. It readily attacks tomato as well as potato, and is capable of causing severe damage. *P. infestans* de By., however, caused the true late blight disease in Simla as elsewhere. Other *Phytophthoras* under study include isolates from brinjals, oranges and apples. The *Phytophthora* from brinjal fruits and seedlings has been identified as *P. parasitica* Dast. (emend.) Ashby.

A critical examination was made of 73 collections of smut of sugarcane (*Saccharum officinarum* and *S. Barberi*) on the basis of spore colour, surface markings, thickness of the spore-wall, and size of spores. It was concluded that the culmicolous smut of sugarcane consists of one species, *Ustilago scitaminea*, with two varieties, var. *Sacchari-Barberi*, with smaller spores, and var. *Sacchari officinarum*, with longer spores than the fundamental species. It was found that a number of identifications of smuts on species of *Saccharum* made by early workers were incorrect, and these have now been rectified and the work submitted for publication. An ovaricolous smut on *S. munja* Roxb. collected at Cuttack was found to be a new species of *Sorosporium*.

In addition to sugarcane smut, seven new species of smut fungi from other hosts have been described.

Work has been commenced or continued on taxonomy of *Synchytrium*, *Cystopus*, *Erysiphe* and *Alternaria*.

III. ADVISORY

One hundred and two specimens of diseased plants were examined for officers of the Departments of Agriculture and University professors, as compared with 85 last year, and wherever possible control measures for the diseases were recommended.

A considerable number of cultures was identified for workers in India and abroad.

IV. MISCELLANEOUS

Workers in India and abroad were supplied with 81 living cultures of fungi as compared with 55 in the previous year, and 229 herbarium specimens as compared with 101 in the previous year. Fifty-five cultures received from outside were added to the culture collection in addition to those added by the staff of the section. Two hundred and thirty-seven specimens were added to the herbarium collection.

Work was continued in co-operation with the Sugar Technology Institute Cawnpore, to study the spoilage of sugar by moulds and bacteria.

A list of new plant diseases recorded in India during 1939 was sent to the International Institute of Agriculture, Rome.

Aeroscopic slides were exposed for Dr. K. C. Mehta in connection with his scheme for investigation of cereal rusts.

V. PROGRAMME OF WORK FOR 1940-41

1. Continuation of work on varietal resistance of cereals to smuts. Modes of infection of crop plants with smuts. Smut control by seed dressings.

2. Diseases due to *Fusarium*. Identification of species. Continuation of work on selection of varieties of gram, pigeon-pea and sann-hemp resistant to wilt.

3. Study of soil conditions favouring development of *Fusarium* root-rots and wilts, and the effects of rotations.

4. Flax rust. Testing of varieties for resistance. Identification of physiological forms.

5. Testing of sugarcane varieties for resistance to smut, red-rot and wilt. Intensive disease surveys in sugarcane experimental stations.

6. Study of possible modes of infection and sources of inoculum of red-rot of sugarcane.

7. Potato spoilage. Identification of causal organisms. Varietal resistance tests.

8. Early and late blight of potatoes. Varietal resistance tests.
9. Taxonomic work on the genera *Phytophthora*, *Alternaria*, *Erysiphe*, *Fusarium*, *Urocystis*, *Synchytrium*, *Cystopus*, *Peronospora* and on certain groups of Indian Ascomycetes.
10. Preparation of a host index of Indian fungi.
11. Identification of virus diseases.
12. A study of root-rot disease of wheat.
13. Collection and identification of specimens, identification of fungi received in culture, and development of herbarium and culture collection.

REPORT OF THE IMPERIAL ENTOMOLOGIST

(HEM SINGH PRUTHI)

I. GENERAL

Now that the Institute has completed four years on its present site at New Delhi, considerable familiarity has been gained with the insect fauna of this region. Several new problems in the domain of applied entomology have to be faced. The habits and biology of many species of economic importance, commonly occurring in Delhi and its neighbourhood, have been studied, but the intense heat and dryness of summer are proving handicaps in their study and preservation in the laboratory. An orchard, containing fruit trees commonly found in the plains of India, has been laid out behind the laboratory building to provide a wider range of host plants of insect pests under observation and also to afford flora for honey bees proposed to be maintained at this Institute for research and demonstration. The orchard and the farm, particularly the entomological area, under various vegetable and other crops, would now be valuable aids in the study, specially of the relative intensity of attack by different insect pests from year to year. The additional staff recently sanctioned for insect population studies will be very useful in this connexion. In this way, it is hoped, considerable advances will be made in the understanding of the fundamental causes of outbreaks of various insect pests, and thereby the methods of their control will be simplified. No less important will be the means, which may become available, for forecasting future pest outbreaks.

The main functions of the Section and its special researches have been the same as last year, except that an additional investigation on the effect of high temperatures on the hibernating pink bollworms inside cotton seed, with a view to find suitable means of sterilizing infested seed, was undertaken at the instance of the Department of Agriculture, United Provinces. The organization and supervision work of the locust warning staff which was put under my charge towards the end of the last academic year was also an additional activity of the Section. Now we are in intimate touch with the locust movements not only in India but in the neighbouring countries in the Middle East as well.

II. SPECIAL INVESTIGATIONS

1. ECOLOGY OF SPOTTED BOLLWORMS (*EARIAS* SPP.) OF COTTON AND THEIR IMPORTANT PARASITES

The fecundity and longevity of *Earias fabia* Stöhl and *Microbracon lefroyi* (D. & G.) were studied at constant temperatures of 16°C, 20°C, 25°C 30°C and 35°C under various saturation deficiencies (S. D.) and results are given below :—

(a) The bollworm (*Earias fabia*).—The average number of eggs laid under 3 mm S. D. was 29.2, 63.5, 246 and 163 at constant temperatures of 16°, 20°, 25° and 30°C respectively. Maximum number of eggs laid by a single female at 25°C and 30°C was 459 and 523 respectively. Thus 25°–30°C seems to be the optimum temperature for oviposition. No eggs were laid at 35°C under 0 mm. and 3 mm. S. D. whereas on an average 9 eggs were laid under 14 mm. S. D.

Adults which had their pre-imaginal period at 35°C were transferred to 25° and 16°C and similarly those reared at 25°C were kept at 16°C and 35°C and their fecundities recorded. Moths similarly reared at 35°C laid on the average 156 and 112 eggs at 25° and 16°C respectively while those obtained from larvæ reared at 25°C laid 116 and 83 eggs at 35°C and 16°C respectively. Moths which had their pre-imaginal and post-imaginal life at 35°C failed to lay any eggs, whereas they were capable of laying a good number of eggs when transferred to lower temperatures after the completion of the pre-imaginal period. Adults with pre-imaginal period at 25°C laid a fair number of eggs at 35°C. Thus while a temperature of 35°C during the whole of the life causes marked sterility, it is not so injurious if acting on the pre or post-imaginal life alone.

The life of the adults is inversely proportional to temperature. The higher the temperature, the shorter the life. The average life of a female moth was 20, 18, 13 and 7 days at 16°, 25°, 30° and 35°C respectively.

(b) The parasite, *Microbracon lefroyi*.—*Earias* spp. are the favourite hosts of this parasite, but for mass-rearing an adequate supply of this host is not available from November to June. Although *Platyedra gossypiella* is known to be parasitised by this species in the field, the practical utility of this alternate host for rearing the parasite during the off-season has been established now for the first time. These larvæ are freely accepted as hosts, provided they are offered in pods of *Hibiscus esculentus*. The oviposition and development of the parasite is normal. This observation has great economic significance, as a large number of double seeds of cotton having hibernating pink bollworms can be collected, stored and utilised as hosts during spring and early summer.

Observations on the fecundity of the parasite at different temperatures have shown that 35°C is too high for oviposition. A temperature of 20°C has been found to be most suitable for this process, the average number of eggs laid at this temperature being 55.4.

The parasite adults, fed on honey solution, lived longer and laid almost double the number of eggs at all temperatures than those which were not provided with food. Humidity within 0 and 3 mm. S. D. has no marked effect on the longevity and fecundity of the parasite. The average longevity of females when fed was 30.3, 27.4, 17.1 and 2.8 days at 16°, 20°, 25° and 35°C respectively. The corresponding figures when the females were not fed were 20, 10, 6.8 and 1.79 days only.

It was planned that the parasites bred at 25°C should be transferred to 16° and 35°C, those bred at 35°C to be transferred to 16° and 25°C and those bred at 16°C to be transferred to 25° and 35°C. It is interesting to note that the parasites which had passed pre-imaginal period at 25°C when transferred to 16°C found the change very suitable. Under such conditions a female laid on an average 70 eggs, the maximum being 159. Females reared at 16°C and transferred to 25°C laid on an average 50 eggs, the maximum being 129. Those reared at 25°C and transferred to 35°C did not lay any eggs. It is therefore, obvious that a temperature of 35°C during the imaginal or the pre-imaginal life of the parasite causes complete sterility and is thus more injurious to the parasite than to the pest.

2. FATAL TEMPERATURES FOR THE PINK BOLLWORM, *PLATYEDRA GOSSYPIELLA* (SAUNDERS)

The investigations of the Department of Agriculture, United Provinces, had previously revealed that the only practical method of controlling the pink bollworm is to prevent the carry-over of the hibernating larvæ inside the double seeds by effective heat treatment. Exposing the seeds to direct sun during April and May was found to be effective and was tried in some parts of the province. This method has its limitations as it could not be applied to large quantities of seed kept by the ginning factories. It was, therefore, advocated that the factories must be equipped with heating machines. Before taking this step, the Director of Agriculture, United Provinces, referred the problem to the Imperial Entomologist for investigation.

Experiments were thus performed, under controlled conditions of temperature, to determine the duration of exposure to various high temperatures to ensure complete mortality of pink bollworm larvæ. It is found that exposure of naked larvæ for about 24-30 hours to 45°C, 1-1½ hours to 50°C, 7-10 minutes to 55°C, 5 minutes to 60°C, 2-3 minutes to 65°C or one minute to 70°C is completely fatal. Thus taking various factors into consideration, the treatment of double seeds in practice should be so designed as to expose the larvæ themselves for 2-3 minutes to a temperature of 65°C or for one minute to 70°C. In order to kill the larvæ completely inside double seeds it was found that an exposure of over 3 hours to 50°C, 40 minutes to 55°C, 15 minutes to 60°C, 7-10 minutes to 65°C or 2-3 minutes to 70°C is necessary.

Double seeds in a single layer were also exposed to the sun on a *kacha* floor. All larvæ inside the seeds died within a period of ten minutes when shade, soil, black bulb and white bulb temperatures were 42°—47°C, 60°—66°C, 57°—73°C and 44°—54°C respectively.

The quantity of seed to be heated, its moisture content and the age of the hibernating larvæ are also important factors which have to be kept in view. The work is in progress.

3. INSECT VECTORS OF TOBACCO LEAF-CURL VIRUS DISEASE IN NORTH INDIA

In the reports of the two previous years it was shown that the whitefly, *Bemisia gossypiperda* M. & L. is a very important vector of tobacco leaf-curl. It can transmit the disease to healthy tobacco from diseased tobacco and several other cultivated and wild plants. In the year under report in addition to testing several alternate hosts examined in 1938-39, transmission experiments with a number of new plants were performed. The maximum percentage of positive results obtained with various hosts and the types of disease resulting in tobacco are given below :—

Alternate hosts.	Maximum per centage of positive trans- missions.	Types of leaf-curl disease caused to tobacco.
<i>Zinnia elegans</i>	46	C, D, X.
<i>Solanum nigrum</i>	94	B, C, D, all mixed with X.
<i>Euphorbia hirta</i>	70	B, mixed with X.
<i>Vernonia cinerea</i>	70	A & C, mixed with X.
<i>Lycopersicum esculentum</i>	20	A.
<i>Launea asplenifolia</i>	44	?
<i>Sida rhombifolia</i>	20	C.
<i>Scoparia dulcis</i>	40	X.

Thus it is evident that the alternate hosts of the tobacco leaf-curl disease are very numerous. There are several other plants, both cultivated and wild, which serve as food plants of the white-fly and some of which show some kind of leaf-curl disease, but they have not yet been tested by experiment whether or not they are actually alternate hosts of tobacco leaf-curl.

A series of dusting and spraying experiments have been performed to control the white-fly in tobacco nurseries and crops early in the season. The results show that there was considerable decrease in the incidence of the disease in sprayed plots as compared with the controls. It is proposed to repeat these experiments on a field scale during 1940-41 and the results will be reported in due course.

The biology of the white-fly vector and its incidence at different times of the season have been carefully studied. The white-fly breeds throughout the year except when it is too hot or too cold. It is most common in tobacco fields in autumn (up to the middle of November) when the incidence of the disease is also very high.

4. PESTS OF FRUITS AND VEGETABLES

The study of the insect pests of fruits and vegetables was continued. The cucurbit fruit flies, *Dacus ciliatus* Loew and *D. cucurbitae* Cog. were serious pests of 'kharbuza' (*Cucumis melo*), karela (*Momordica charantia*), gherua (*Luffa aegyptiaca*) and gourd (*Lagenaria vulgaris*). The fruits were infested by both the species from July to October, the incidence ranging between 40 and 80 per cent. respectively. As result of large scale rearing of these flies from fruits of gherua in nature, the Braconid, *Opius compensans* Silv. was found for the first time parasitising 10-12 per cent of the puparia in October and beginning of November. *Opius fletcheri* Silv., the well known Braconid parasite of *D. cucurbitae*, was neither found in the field nor did it emerge in the breeding cages in the laboratory.

The experimental variety of safflower in the plots of the Imperial Economic Botanist again suffered heavily from the attack of the fruit fly, *Acanthiophilus helianthi* Rossi. This year flies of this species appeared in the field about the end of December. After completing the first generation in the terminal shoots, the fly infested seriously the floral buds which had started appearing on the plants about the middle of January. The pest showed marked preference for the less spiny varieties, as compared to the spiny ones, the incidence in variety No. 30 which is almost spineless, increasing from 15 to 100 per cent by March, whereas the attack in the spiny varieties during this month was only 5-15 per cent. In variety No. 30 the population of the fly increased enormously. In April it increased from 15 to 80 per cent. Another factor responsible for the increase in the fly population was that the parasites, viz., *Tropideucoila* sp. and *Ormyrus* sp., were not common, the parasitisation by both the species being about 5 per cent during March and April. Thereafter, however, it increased to 40 per cent in the middle of May about the time the crop was harvested. After the cultivated varieties were over, the fly was found breeding in wild safflower growing on the sides of field drains and other uncultivated areas. Systematic weeding of wild safflower in autumn should prove effective in the control of the pest.

5. STUDIES ON INDIAN PARASITES

Systematic studies on some important groups of parasites were continued. The study on the Braconid genus *Microbracon* was extended to include an examination of all such Indian species, as might be suspected to belong to this genus. This involved the correct appraisalment of the systematic status of many forms hitherto described under *Microbracon* and other allied genera and has resulted in the restriction of the number of true species of *Microbracon* in India to less than a dozen. An examination of a large number of specimens of *Apanteles* (Braconidae) showed that *A. flavipes* Cam. is a fairly common species in this country parasitising such well known borer pests as *Chilo zonellus* and *Argyria sticticrasis*. The Ichneumonid genus *Pristomerus* was under study, specially with reference to the probable identity of two species; *P. euzopherae* Viereck and *P. testaceus* Morley.

Some of the old material of parasites in the Imperial Pusa Collection was worked out and identified, while the identification of some named species was checked and brought up-to-date by reference to the latest publications on the subject. Such a systematic revision of two Chalcidoid families—Agaonidae and Torymidae—was completed during the year under report, while that of the Ichneumonoid family Evanidae was undertaken.

In the previous year's report, reference was made to the data collected on the biology, hosts and distribution of parasitic Chalcidoidea. During the present year similar data relating to two other important superfamilies of parasites, *viz.*, Serphoidea and Bethyloidea, were collected. A catalogue of the Indian species of Evanidae was published and catalogue of Braconidae and Serphoidea were under preparation : the latter is now ready for the press.

The insect fauna of Afghanistan has been but little explored and information on the parasites occurring in this region is non-existent. During the year under report, a small collection of parasites, made in Afghanistan by the Agricultural Delegation, sent out from this country, was under examination. The study is still incomplete but several interesting species have already been noted in the collection, *e.g.*, *Monodontomerus aereus* (Torymidae) bred from *Euproctis signata* and known to occur in Europe and America, about half a dozen species each of other Chalcidoidea and of Telenominae and species of *Apanteles*, *Glyptomorpha* and *Microbracon*.

The routine work of the identification of parasites, received from outside workers, also offers opportunities for the examination of many interesting species, some of which are noted below :—*Eretmocerus masii* Silv., parasitic on the nymph of *Bemisia gossypiperda* M. & L. at Pusa ; *Encarsia isaaci* Mani on *Aleurolobus barodensis* and *Neumoskellia bergii* infesting sugarcane at Delhi ; *Goniozus indicus* Muesebl. from *Emmalocera depressella* at Delhi ; *Apanteles creatonoti* Viereck, *var. n.*, parasitic on *Diatrea* sp. at Calcutta and *A. ruidia* Wilk. bred from *Sphenarches caffer* and from *Hymenia fascialis* (?) at Delhi, the last two parasites having been unrecorded, so far, from their present hosts.

6. IMMATURE STAGES OF INDIAN INSECTS

As the immature stages of many insect pests are quite different from their adults, it is necessary for proper diagnosis of a pest to know how its young ones look like, inasmuch as it is the latter which do the most damage. For this purpose immature stages of insects are studied in the insectary and the illustrations of various stages are made in colour. The demand for such colour plates may be judged from the fact that during the year over five hundred colour plates were supplied to various departments of agriculture, universities, etc., throughout India. This useful work is severely handicapped for want of air-conditioning arrangements in the insectary, as a result of which many important insects undergo a high rate of mortality during summer.

During the year, over 120 species of insects were reared and closely studied in the insectary. *Heliothis peltigera* was noted as a serious pest of

safflower, passing two generations from the middle of November to the middle of March on this plant. *Amsacta moorei*, a serious pest of *kharif* crops, completed three generations from June to September. By careful observations it was established that *Tarache notabilis*, a minor pest of cotton, remains under hibernation for about 8 months. *Laphygma exigua*, a serious pest of lucerne, berseem, etc., completed nine generations in a year, aestivating for about 2 months from the middle of August.

7. INSECTICIDES

Work under this head was done mainly with the object of testing the value of some insecticides of vegetable origin, and further experiments on the preparation and trial of such insecticides were carried out along lines mentioned in last year's report. Benzene extract of the seed of *Tephrosia candida* was successfully sprayed against *Bagrada picta*, aphids on cruciferous crops and against *Bemisia gossypiperda*. Benzene and kerosine extracts of the seed of *Pongamia glabra*, a well known shade tree, gave good results against *Pulvinaria* sp., *Bagrada* sp., membracids and aphids. Trials were also made with aqueous extracts of the flowers of *Vernonia* sp. and with the leaves of *Argemone mexicana*, two weeds common all over India, but the results were inconclusive. *Derris* extract was found fairly effective against aphids and *Bagrada picta* and *Derris* dust against *Plutella maculipennis*.

Some trials with lead chromate, used both as spray and as dust, made against *Phyllotreta* spp. and a Cetonid beetle on *Eugenia operculata*, showed that this insecticide is quite good, though less active than lead arsenate.

III. GENERAL OBSERVATIONS ON INDIAN INSECT PESTS

Intensive surveys of the insect fauna of the Estate of the Institute and environs of Delhi were carried out but on account of limited travelling grant only a few tours in other parts of the country were possible. We had this year a very useful contribution to our knowledge of insect fauna of Afghanistan made possible by the visit of the Assistant Entomologist, Dr. Taskhir Ahmad, to that country as a member of the Agricultural Delegation.

A. DELHI AREA

The survey of aphids of Delhi was continued. There was a serious outbreak of *Rhopalosiphum pseudobrassicae* Davis on *Brassica* plants. *Myzus persicae* Sulz. was common on potato, tobacco and several other plants. It was found that in this area most of the aphids disappear in the beginning of May but *Aphis laburni* Kalt., *A. maidis* Fitch and *Brachyunguis carthami* continued to breed till the end of October.

(i) The following insects appeared in pest Kalt. form during the year :—

Amsacta moorei Swinhoe damaging cowpea, *Sesamum indicum*, 'guar' (*Cyamopsis psoraloides*) and several other *kharif* crops. Effective control of this pest was carried out on the estate by using light traps. Forty petromax lights over an area of 400 acres captured over 52,000 moths, 33 per cent of

which were female. *Euxoa segetum* Schiff. on cabbage and gram; *Laphygma exigua* Hb. on chillies, cowpea and linseed. *Heliothis peltigera* Schiff. and *Acanthiophilus helianthi* Rossi on safflower. *Plusia nigrisigna* Walk. boring gram pods. *P. orichalcea* Fab. on leaves of lucerne, *Meliolotus parviflora* and *Trigonella foenum-graecum*. *Leucinodes orbonalis* Guen. and *Euzophera perticella* Rag. on brinjal. *Euchrysops cnejus* Fab. on cowpea and *Cajanus cajan*. *Hellula undalis* Fab. on cabbage leaves. *Platyedra gossypiella* (Saund.) and *Earias insulana* (Boisd.) on cotton. *Chilo zonellus* Swinh boring stems of maize and *Andropogon sorghum* and *Argyria sticticraspis* Hamp. and *Scirpophaga nivella* Fb. on sugarcane. *Aphis laburni* Kalt. on lucerne, *Lathyrus sativus* and *Meliolotus parviflora*. *Aphis maidis* Fitch on maize, *Andropogon sorghum* and barley. *Myzus persicae* Sulz. on tobacco. *Rhopalosiphum pseudobrassicae* and *Bagrada picta* Fb. on several cruciferous plants. *Engytatus tenuis* Reut. on tobacco and bottlegourd. *Urentius echinus* Dist. on brinjal. *Empoasca devastans* Dist. on cotton. *Metacanthus pulchellus* Dall. on bottlegourd. *Hypera medicaginis* Mshl. on lucerne, and *Chaetocnema basalis* Baly on *Andropogon sorghum*. *Longitarsus belgaumensis* Jac. on leguminous crops. *Phyllotreta cruciferae* Goetz. on cruciferous plants. *Aulacophora foveicollis* Lucas on bottlegourd and melon, and *Mylloceris laetivirens* Mshl. on soybean. *Phytomyza atricornis* Meig. mining leaves of cruciferous and several other plants. *Dacus ciliatus* Loew and *D. cucurbitae* Coq. infesting melon and bittergourd. *Poeciloceris pictus* Fab. on maize, 'papaya' and grape vine.

(ii) The following insects noted as pest in 1938-39 were less common this year :—

Agrotis ypsilon Rott. and *Heliothis armigera* Hb. on gram, *Cirphis unipuncta* on maize and 'khesari', *Phthorimaea operculella* Zell. on potato, *Plutella maculipennis* Curt. on cabbage, cauliflower and knol-kohl, *Emmalocera depressella* Swinh. on sugarcane, and *Gryllulus domesticus* L. on cotton.

(iii) The following insects were noted for the first time at Delhi :—

Tarucus theophrastis Fab. on *Zizyphus numularia*. *Laelia testacea* Wlk. on castor. *Tridactylus variegatus* Latr. on cotton, lucerne and hollyhock. *Argina cribraria* Clerck. on sannhemp. *Foca straminea* Hope on *Cyamopsis psoraloides*. *Ensina sororcula* Weid. on lucerne. *Melanostoma mellinum* L. on berseem. *Thea bisoctonotata* Muls. predated on aphids infesting mulberry and cabbage. *Eublemma parva* on safflower and *Laius externenotatus* Pic. on lucerne, tomato and several other crops.

(iv) The following new host plants were recorded for various important insect species :—

Cotton, castor, *Trichosanthes dioica*, brinjal, oats, hollyhock and groundnut for *Laphygma exigua* Hb. *Ocimum sanctum* for *Heliothis peltigera* Schiff., hollyhock for *Dichochrois punctiferalis* Geun., castor for *Phycita clientella* Z.; *Hibiscus sabdariffa* for *Anomis flava* Fab.; soybean for *Maruca testulalis* Geyer.; sannhemp and *Phaseolus radiatus* for *Euchrysops cnejus* Fb. and wheat for *Dasychira securis* Hb.

B. OTHER AREAS IN INDIA

Other areas visited during the year include Nagpur in the Central Provinces, Coimbatore and Mysore in South India and Dacca, Jorhat, etc., in Bengal and Assam.

(i) At Nagpur, *Indarbala quadrinotata* and *Stromium* sp. on citrus, *Achaea janata* L. moths puncturing and sucking citrus fruits and *Pachydiplosis oryzae* on rice were the chief pests noted.

(ii) At Coimbatore and Mysore, the more important pests observed were, *Pempheres affinis* Fst. and *Empoasca devastans* Dist. on cotton, *Phthorimaea heliopa* Low. on tobacco, *Eupterote canaraica* M. on cardamom and *Zeuzera coffae* Nietn. on coffee.

(iii) In Bengal and Assam the following were important pests :—

At Dacca (Bengal), *Schoenobius bipunctifer* Wlk., *S. immeritalis* Wlk., *Hispa armigera* Ol., *Spodoptera mauritia* Boisd. and *Nymphula depunctalis* Guen. on paddy. *Cryptorhynchus gravis* Faust. and *Plocaederus pedestris* White on mango and *Aleurocanthus nubilans* Buckton on betel-vine. At Shillong, *Eriosoma lanigerum* Hausm. on apple. At Jorhat, *Scirpophaga nivella* seriously infesting sugarcane crop, *Spodoptera mauritia* Boisd., *Hispa armigera* Ol., *Leptocoris varicornis* Fb. and *Schoenobius bipunctifer* Wlk. on paddy, *Phaedon assamensis* Baly on mustard, *Monohammus versteegi* Rits, *Chloridon aleurne*, *Rhynchocoris humeralis* Thunb. on citrus, *Cryptorhynchus gravis* Faust. on mango and *Xylotrupes gideon* L. on pine apple.

C. INSECT FAUNA OF AFGHANISTAN

The outstanding feature of the insect fauna of this neighbouring country is that it shows marked variations from place to place. The Laghman and Jalalabad valleys are characterised by the presence of tropical and sub-tropical insects similar to those found in North-West India. The Kabul plateau is rich in Aphididae and Coleoptera, particularly Chrysomelidae, Coccinellidae and Curculionidae. The most common Lepidopterous insects observed were *Hyponomeuta padella* L. *Cydia pomonella* (L.), *Cacoecia pomivora*. The low lying steppe in Afghan Turkistan formed suitable breeding grounds for various species of locusts, particularly *Calliptamus siccus* Burm. and *Docostaurus morrocanus* Thunbg. The chief cotton growing belt in the north is free from bollworm pests so serious in several other countries. In the central Highlands of Hazarajat Aphids, *Hyponomeuta padella* L., *Cydia pomonella* (L.) and *Euproctis signata* Blanch. were the most serious pests. In the south western Afghanistan (Kandahar province) *Sphenoptera laferti*, *Aulacophora foveicollis* Lucas, *Myiopardalis pardalina* Big. and *Cydia pomonella* (L.) were the common species.

IV. WORK OF THE LOCUST WARNING ORGANISATION

Several surveys were made by the locust staff in the desert areas of Mekran, Lasbela State, Northern Baluchistan, Bahawalpur, Sind and

Rajputana. Intensive local surveys were carried out almost daily in the neighbourhood of Pasni, Gwadar, Turbat and Panjgur in South Baluchistan (Mekran), Ambagh (Lasbela State), Sukkur (Sind) and Barmer, Nokh, Chhachro and Sardarshahr (Rajputana).

The spring breeding of 1939 was very much prolonged in Mekran, a hopper of V stage being traced in November. The highest population density recorded was 1,980 per square mile in June 1939 in the Kalamat-Makola area. It began to decline in August and reached its minimum during December and January. Spring breeding started in March 1940 but the concentrations developed were thin and mainly limited to Pasni and Turbat areas. There were presumably two generations during the spring and the summer months.

In Lasbela, the population which had reached a density of 5,400 locusts per square mile at Chandragup and Kund in June 1939 started decreasing soon after. With the approach of monsoon precipitations breeding was stimulated and two generations appear to have been produced, but the number of locust remained small. The autumn and winter months maintained low population. After the production of first spring generation in the Kalamat-Makola area, some of the locusts seem to have been attracted by the rainfall received in March 1940 and started breeding in Lasbela and Hingol area. This was followed by the drought conditions in May which checked further breeding.

The Kachhi valley in Baluchistan showed a population of 19,000 locusts per sq. mile in June 1939. The population dwindled completely by about autumn. Some of the adults produced in June and July probably migrated to the Sardarshahr area in Rajputana which had previously received some fair amount of rain. Breeding soon started in this area and later on extended to the Bikaner, Nokh and Barmer areas which also received some rain. The locust concentrations built up at these places were of limited density. There was very little overwintering and spring breeding remained unobserved in spite of some scattered rainfall during the winter months.

It would thus appear that there was no heavy breeding in 1939 anywhere in Mekran or Lasbela State. Small concentrations were built up in the Kachhi area and some of the locusts migrated to the Rajputana desert but failed to develop into thicker concentrations. There was limited migration from the Rajputana desert to the west during autumn and, therefore, scanty breeding was observed during the spring of 1940 in Mekran. The locust population at the end of May 1940 was not high anywhere in Mekran, Lasbela, Sind or Rajputana.*

*Since writing the above there has been remarkable development. There was abundant rainfall in Rajputana during July-August 1940, which lead to intensive breeding of the locust, resulting in incipient swarming. Details will be given in the next Report (1940-41).

V. THE IMPERIAL PUSA COLLECTION

The registration of named specimens in the Collection, and the preparation of card catalogues, giving information about the hosts, distribution and seasonal appearance of various species, were continued. During the year under report, about 17,000 specimens belonging to about 2,600 species were registered, bringing the total registered collection to about 85,000 specimens of over 8,500 species. Now, only some families of Lepidoptera and Coleoptera collections remain to be registered. The Collection is expanding rapidly but due to heat and dust in summer some valuable specimens are being damaged and lost. The need seems to be felt all the more for its proper housing and protection, which can only be possible by the provision of well-made insect cabinets and the air-conditioning of the collection rooms.

A small, but very varied, part of the Collection is in the Sectional Museum on display. This collection presents, in styles ranging from the popular to the highly technical, the life and habits of the more important insect pests of India, suitably illustrated with drawings, models and actual specimens of their hosts, habitats, etc., and is frequently consulted by students and laymen. During the year, the identification of and information on the various species displayed was checked and brought up-to-date, while considerable labour was expended in renovating, repairing or replacing specimens. Many new exhibits of important insect pests of India were also added.

As before, the identification of the unnamed material, whether present in the Collection or received from outside sources, was proceeded with and in this work, valuable assistance was again received from the Imperial Institute of Entomology, London. Among other workers who helped in the identification of specimens, mention may be made of Mr. H. K. Munro, Pretoria, South Africa and Mr. T. Bainbrigge Fletcher, Stroud, England.

During the year under report, about 60 named species, which had not been represented in the Collection before, were added to it. They were collected by the staff or received in exchange or as donation.

VI. ADVISORY

1. IDENTIFICATION OF INSECTS

Over one hundred consignments of insects comprising nearly 300 species were received from different parts of India and neighbouring countries and identified as far as possible. Some of the noteworthy identifications are given below :—

Mesomorphus villiger Blanch., swarming in large numbers inside houses, from the Director, Harcourt Butler Institute of Public Health, Burma, Rangoon, and from the Sugarcane Entomologist, Bihar, Pusa.

Empoasca flavescens Fab. and *Vulturinus ornatus* from the Entomologist, Tea Research Institute, Talawakelle, Ceylon.

Eurygaster maura L., infesting wheat ears from the Agricultural officer, Baluchistan, Quetta.

Lytta picta Cast. and *L. tenuicollis* Pall., damaging paddy, from the Bundi Agricultural Syndicate, P. O. Talera, Rajputana.

2. INFORMATION ABOUT INSECT PESTS & PARASITES

Over 110 enquiries were received from correspondents in India and abroad asking for information about the distribution, biology and control of insect pests, etc., and were answered as far as possible. A few important cases illustrating the nature of these enquiries are given below :—

Detailed instructions about baiting locusts, grasshoppers and crickets were given to the Agricultural Officer, Jaipur State, Secretary, Gulmarg Club, Kashmir and to the Department of Agriculture, North West Frontier Province.

Information on the biology and control of termites attacking cotton and sugarcane was supplied to the Entomologist, Incharge Black-headed Cricket Scheme, Sind, and Jailakshmi Sugar Co., Doiwala, Dehra Dun.

Advice for storing grains safely from insect pests was given to the Officer Incharge of Supplies, Bareilly ; the Managing Director, Punjab Flour Mills, Lahore ; and the Secretary, Pure Food Products Ltd., Calcutta.

References to literature on tea fruit fly, *Adrama austeni* Hendel were supplied to the Entomologist, United Planters' Association of South India.

An annotated list of termites in the Imperial Pusa Collection was supplied to the Forest Entomologist, Dehra Dun.

A brief account of important pests of oilseed crops in India was prepared and supplied to the Agricultural Commissioner with the Government of India.

Advice for the control of the potato moth, *Phthorimaea operculella* Zell. was given to the Deputy Director of Agriculture, Patna ; Superintendent, Maclaren Hospital, Dehra Dun ; and Messrs. The Cold Storage Co., Meerut.

3. BEE-KEEPING

A large number of requests for advice regarding training centres for apiculture in India and abroad, literature, bee-keeping appliances, importation of foreign bees, cross-breeding of Indian and foreign species and bee-diseases were received from various parts of India and answered. The demand for comb-foundation has increased enormously and a large quantity of foundation sheets, prepared in this laboratory, as also zinc queen-excluders, were supplied to bee-keepers all over India, including Nepal. Considerable difficulty has been felt in meeting the heavy demand for comb-foundation sheets, due mainly to the uncertainty of obtaining pure raw bees' wax in sufficient quantity. Numerous requests for the demonstration of comb-foundation manufacture and exhibition of bee-keeping appliances were received during the year ; among such demonstrations held during the year one was

for the delegates of the first All-India Bee-keepers' Conference held in Delhi, and another for the Industries Department, Delhi.

VII. MISCELLANEOUS

Mosquito control operations on the Estate were supervised as usual. The spring mosquito, *Culex fatigans* was found breeding throughout the year in sludge, water drains, unused wells and other accumulations of dirty water. Larvae of *Anopheles culicifacies* and *A. sulpictus* were common in irrigation channels and those of *Aedes vittatus* in quarries, etc.

Anti-fly campaign was intensified on the estate during autumn and spring when flies were found actively breeding in manure pits of the dairy and the silt deposit of the sludge tanks. Covering of manure with loose earth did not prove fully effective in stopping the breeding. The traps designed by this section immensely helped in reducing the population of adult flies. These fly traps are now greatly in demand and are being regularly used by the Health Departments and Government farms.

A number of research papers were examined and reported upon with regard to their suitability for publication in the journals of the I. C. A. R. and other departments and universities.

Numerous consignments of grains meant for export were properly treated to make them insect free and certificates issued accordingly.

VIII. PROGRAMME OF WORK FOR 1940-41

Research work will be continued more or less on the same lines as during 1939-40. Work on population of insects will be initiated. Owing to the likelihood of starting another locust cycle, attention may have to be diverted from usual work to that on locusts.

REPORT OF THE SECOND ENTOMOLOGIST (DIPTERIST)

IN CHARGE OF

SCHEME* FOR RESEARCH ON INSECT PESTS OF SUGARCANE

(P. V. ISAAC)

Research work on insect pests of sugarcane was continued at New Delhi and at the sub-stations in Karnal, Pusa, and Coimbatore.

1. FIELD OBSERVATIONS

Field observations on major pests were made at New Delhi, Karnal, Pusa, and Coimbatore.

Scirpophaga nivella F., the top-borer, was first noticed in canes at New Delhi in the early part of July. Moths from this brood began laying eggs during August. Larvae of the October brood entered into hibernation till the following February. Moths from the over-wintering brood oviposited on the ratoon crop during March-April. The stem-borer, *Argyria sticticraspis* Hmps., was noticed to be present in small numbers in July, but later on became insignificant in the field. *Emmalocera depressella* Swinh. was prevalent in small numbers during July and continued to be so, subsequently. In June, it was the most prominent amongst the borers in the field. A minor attack by *Sesamia uniformis* Ddgn., the stem-borer, was noticed in July and August. In the following April it was the common stem-borer pest in the ratoon crop. The stem-borer, *Raphimetopus ablutella* Zell., was present in small numbers in the ratoon crop during April 1940. *Pyrilla* spp. was a minor pest during the year under report.

Saccharam ravennae Linn., a wild grass growing in plenty round about the Imperial Agricultural Research Institute, was found to be attacked by *Scirpophaga nivella* F., *Sesamia uniformis* Ddgn., and *Emmalocera depressella* Swinh.

Detailed life-history of *Sesamia uniformis* Ddgn., the stem-borer, was worked out in the laboratory. The number of eggs laid varied from 78 to 84. The total larval period lasted for 34 to 44 days and the pupal period for 8 to 9 days during June and July, and during August-September, the larval period lasted for 33 to 57 days and the pupal period 8 to 11 days.

Scirpophaga nivella F., the top-borer, was kept under observation. The number of eggs laid by a single moth varied from 51 to 118. During August-September the total larval period lasted for 23 to 27 days and the pupal period 7 to 9 days. Adult moths lived for 3 to 4 days.

Detailed life-history of *Asamangulia cuspidata* Maulik., the leaf-miner of sugarcane, was also worked out in the laboratory.

Fecundity studies on the borer moths of sugarcane were carried out in field cages and by dissection.

*This represents a summary of the full report submitted to the Imperial Council of Agricultural Research who finance the scheme.

2. STUDIES ON THE INCIDENCE OF BORERS IN DIFFERENT VARIETIES OF CANE

Karnal

The incidence of pests on five selected varieties of sugarcane, viz., Co. 285, Co. 312, Co. 313, Co. 331 and Co. 421, was noted during the growth of the crop and at harvest time. Varieties Co. 331, Co. 421 and Co. 285 showed less attack by *Scirpophaga nivella* F., than varieties Co. 313 and Co. 312. In the case of *Emmalocera depressella* Swinh., the five varieties can be grouped as follows regarding varietal susceptibility, Co. 285, > Co. 331 = Co. 312, > Co. 313 = Co. 421.

Pusa

Study of the incidence of pests on two selected varieties of sugarcane grown in replicated plots during the growth of the crop and at harvest time was carried out and the percentage of canes attacked by *Scirpophaga nivella* F. was found to be less in Co. 331 than in Co. 210.

Coimbatore

Scirpophaga nivella F., the top-shoot borer, was prevalent throughout the year in fairly large numbers. *Argyria sticticrasis* Hmps., the stem-borer, was abundant on the young shoots of sugarcane, when the plants were about a month old. *Diatraea venosata* Wlk., the stalk-borer, started when the crop was about 3 months old and continued till the canes were harvested.

3. STUDIES ON THE INCIDENCE OF BORERS UNDER DIFFERENT CONDITIONS OF PLANTING

Studies on the incidence of borers under different conditions of planting were started in Meerut and Bhopal with the co-operation of the authorities concerned. In Meerut the variety Co. 312 was planted according to two methods, viz., (i) the Java method of planting cane setts in deep trenches and (ii) the local flat method of planting cane setts in furrows 2 inches deep. In Bhopal varieties Co. 244 and Co. 421 were planted according to three methods of planting, viz., (i) the Java method in deep trenches, (ii) deep furrow method and (iii) Mysore method.

4. STUDY OF THE MID-RIB IN RELATION TO RESISTANCE AGAINST THE TOP-BORER, *SCIRPOPHAGA NIVELLA* F(a) *Field observations*

At Bhopal during October 1939, Co. 404, which has a soft mid-rib, was the most badly attacked. Co. 331 and Co. 421 both with rather hard mid-ribs showed a good resistance to the top-borer.

At Pusa during November 1939, the incidence of top-borer in varieties Co. 432 and Co. 356, both with rather hard mid-ribs, was 16.5 and 16.6 per cent respectively, compared to 43.5 per cent attack in variety Co. 508 which has a rather soft mid-rib.

At Sardarnagar (near Gorakhpur) during February 1940 the incidence of the top-shoot borer in varieties Co. 421 and Co. 432 both with hard mid-ribs was 48 and 8 per cent respectively as compared to the varieties Co. 419, and Co. 290, with soft mid-ribs, which had 60 and 87 per cent attack respectively.

At Coimbatore during March 1940, mid-rib sections of certain varieties of sugarcane were studied with the help of the Sugarcane Expert. It was seen that the varieties found in the field to be resistant to top-borer, when compared to more susceptible varieties, had more lignin towards the lower surface of the mid-rib, making it more difficult for the larva of the top-borer to bite into the mid-rib by way of which it gets into the top bud.

(b) *Habits and structure of first and second instar larvae of Scirpophaga nivella F.*

This was studied because it is the first instar larva that gets into the shoots and the larva is unable to leave the first shoot it has entered and get into another shoot. The first instar larva is very active, crawling about with great ease on any part of the plant. The second stage larva is a very sluggish creature with thick abdominal segments. When once removed from the shoot, it is not able to bite through and enter it again. It is unsuited to move about except in its burrow which was started in its first instar stage.

5. BIOLOGICAL CONTROL RESEARCH

Some new parasites were bred in the laboratory. These were :—

1. *Cristatithorax quadricolor* Girault on *Lestodryinus pyrrillae* Kieff.
2. *Lygocerus rufipes* (Thoms.) on *Chrysopa virgestes* Banks.
3. An egg parasite and a larval parasite, both unidentified on *Chrysopa virgestes* Banks.
4. *Elasmus* sp., on *Asamangulia cuspidata* Maulik (grub).
5. *Microbracon* sp. on *Asamangulia cuspidata* Maulik (grub).
6. Unidentified pupal and grub parasites on *Asamangulia cuspidata* Maulik.
7. Unidentified parasites on *Dactylopius saccharifolii* Green.

Important parasites and predators studied in the laboratory were :—

(1) *Epipyrops melanoleuca* Fletcher.—The bionomics of this parasite was fully studied. The larva spends its life cycle on a single host. It is physically impossible for it to take to a second host as the mouth parts undergo changes once the parasite clings to a host,

(2) *Chrysopa virgestes* Banks.—Grubs feed both on eggs and nymphs of *Pyrilla* spp. A single grub feeds on nearly 200 eggs or an equal number of nymphs. Unfortunately some parasites retard its multiplication and reduce its value to the cane grower.

(3) *Parasites of Asamangulia cuspidata* Maulik.—Observations were also made on the habits and behaviour of three parasites of the sugarcane hispa, *Asamangulia cuspidata* Maulik.

(4) *Lestodryinus pyrrillae* Kieff.—This parasite has been found to hibernate in winter (4 to 5 months) and to aestivate in summer for a little over 2 months. It thus avoids extremes of temperature. This parasite is attacked by a hyper parasite, *Lygocerus rufipes* (Thoms.)

Biological control field operations 1939-40

Mass liberations of *Trichogramma minutum* Riley against the stem-borer, *Argyria sticticraspis* Hmps., were conducted in the Betiah Estate farms near Sugauli, North Bihar. Statistical analysis of the results as given below show that *Trichogramma* did check the progress of the aforesaid borer as well as that of the root-borer *Emmalocera depressella* Swinh.

Average percentage of canes attacked by stem-borer and root-borer at the time of harvest :—

		Experi- men- tal plot.	Control plot.
Lalseriah . . .	{ Total <i>Argyria sticticraspis</i> Hmps., attack	10.2±0.40	29.4±0.96
	{ Total <i>Emmalocera depressella</i> Swinh., attack	21.2±0.86	43.2±1.12
Madhopore . . .	{ Total <i>Argyria sticticraspis</i> Hmps., attack	12.2±0.91	14.7±0.64
	{ Total <i>Emmalocera depressella</i> Swinh., attack	9.2±0.68	31.7±1.27

There is definite evidence to show that *Trichogramma* was effective in controlling the stem-borer and the root-borer.

Parasites of *Asamangulia cuspidata* Maulik. brought this pest under complete control without any artificial aid in August 1939 when there was a threatened outbreak and *Telenomus beneficiens* (Zehnt) exercised considerable check on the top-borer *Sciropophaga nivella* F.

Anomala beharensis Arrow., in Sugauli.—In April 1940, while examining dead hearts at Sugauli it was observed that nearly 70 per cent of the dead hearts were caused by a ruteline beetle *Anomala beharensis* Arrow., the adults of which gnaw the underground portion of the stem.

6. THE REGIONAL SURVEY OF SUGARCANE BORER POPULATIONS

The Regional Survey of Sugarcane borer population was reorganised. The scheme was intended to cover seventeen regions in the provinces and

states. From the beginning of 1940 the number of regions was reduced to nine. Detailed instructions and entry forms were prepared for the new scheme in consultation with Prof. Mahalanobis.

7. MORPHOLOGICAL STUDIES

The study of the external morphology of the larvae and pupae of the lepidopterous borers in sugarcane with a view to prepare a key for their identification was continued. The results are being written up.

A summary of the work done on the Biological Control of Sugarcane pests in India was prepared. A summary of the work on Sugarcane pests in India during 1939 was under preparation.

APPENDIX I.**Gazetted staff of the Institute**

Director Rao Bahadur B. Viswa Nath

Agriculture

Imperial Agriculturist . . Mr. M. Wynne Sayer. . Mr. Sayer was on leave throughout the year and Mr. Arjan Singh was in charge of the Section.

Assistant Agriculturist . . Mr. Arjan Singh

Statistician Mr. P. V. Krishna Iyer.

Farm Superintendent, Karnal. Mr. A. R. Khan.

Cattle Superintendent, Delhi . Vacant.

Cattle Superintendent, Karnal. Vacant.

Engineering Assistant . . Mr. A. K. Kaul.

Botany

Imperial Economic Botanist . Dr. B. P. Pal.

Second Economic Botanist . Dr. S. Ramanujam.

Assistant Economic Botanist . Rai Sahib Kashi Ram . On leave for one month from 1st June, 1940, preparatory to retirement.

Superintendent, Botanical Sub-station, Pusa. Mr. R. D. Bose. . . The post is temporary. On Mr. Bose's appointment as Assistant Economic Botanist Mr. Hukum Singh, Assistant, Botany Section, was appointed to officiate as Superintendent from 18th June 1940.

Second Assistant Economic Botanist. Mr. R. B. Deshpande (Offg.)

Agricultural Chemistry and Soil Science

Imperial Agricultural Chemist Rao Bahadur B. Viswa Nath.

Assistant Agricultural Chemist Mr. J. N. Mukerji.

Assistant Agricultural Bacteriologist. Mr. N. V. Joshi . . . } Retired from service with effect from 15th April 1940, Dr. S. V. Desai was appointed to the post.

Second Assistant Agricultural Bacteriologist. Dr. S. V. Desai . . . }

Entomology

Imperial Entomologist . . .	Dr. H. S. Pruthi.	
Second Entomologist (Dipterist.)	Mr. P. V. Isaac.	
Biological Control Research Officer.	Dr. J. A. Muliyl . . .	The post is temporary.
Assistant Entomologist . . .	Dr. Taskhir Ahmad .	
Second Assistant Entomologist	Dr. K. B. Lal.	
Assistant Locust Entomologist.	Dr. K. D. Baweja.	
Superintendent, Locust Sub-station, Karachi.	Dr. S. Mukerji.	

Mycology and Plant Pathology

Imperial Mycologist . . .	Dr. G. Watts Padwick.	
Assistant Mycologist . . .	Dr. M. Mitra.	
Second Assistant Mycologist .	Dr. B. B. Mundkur.	
Plant Pathologist for Sugarcane Diseases.	Dr. B. L. Chona . . .	The post is temporary.
Assistant Sugarcane Mycologist	Mr. L. S. Subramaniam .	Ditto.

Sugarcane Station, Coimbatore

Sugarcane Expert . . .	Rao Bahadur T. S. Venkatraman.	
Second Cane Breeding Officer .	Mr. N. L. Dutt.	
Assistant Sugarcane Expert .	Mr. R. Thomas.	
Geneticist	Dr. N. Parthasarathy .	Ditto.

APPENDIX II

Training of students and research workers during 1939-40

(a) Awarded post-graduate Diploma of the Institute

Name	Subject of Thesis
1. A. B. Joshi (C.P.)	A cytogenetical study of an interspecific hybrid in tobacco.
2. G. S. Murti (Madras)	Rust resistance in a barley cross.
3. R. M. Arora (U. P.)	Loose smut in wheat.
4. S. L. Juneja (Punjab)	Part I—Causes of poor setting in some crosses of chillies. Part II—Causes of poor setting in some crosses of gram.
5. A. Sen (Bengal)	Drain-gauge studies at Pusa.
6. W. V. B. Sunder Rao (Madras)	The isolation of ammonia oxidising organisms.
7. A. P. Kapur (Punjab)	The biology of coccinellid beetles.
8. C. B. L. Bhargava (Rajputana)	The ecology of <i>M. lefroyi</i> .
9. R. S. Mathur (U. P.)	The control of plant pathogens by biological antagonism.
10. S. Y. Padmanabhan (Madras)	Physiologic Specialisation in fungi.

(b) Awarded Post-graduate certificate in Agriculture

1. Khan Mohd. Khan (N. W. F. P.)	
2. Khan Sadiq Husain Ansari (Punjab).	..
3. H. D. Naithani (U. P.)	
4. J. C. Chakravarty (Assam)	
5. M. C. Joshi (Ajmer-Merwara).	

(c) Post-graduates under training during the year

Name	Subject	Date of admission
1. J. N. Misra (U. P.)	Agriculture	October, 1939.
2. Ranbir Singh (Punjab)	Do.	Do.
3. N. Y. Karkare (C. P.)	Do.	Do.
4. J. N. Sharma (U. P.)	Sugarcane Breeding	Do.
5. G. P. Seth (U. P.)	Do.	Do.
6. M. J. Deshmukh (C. P.)	Botany	November, 1938.
7. Mohd. Jafar (Hyderabad)	Do.	Do.
8. Y. R. Mehta (U. P.)	Do.	Do.
9. H. C. Mirchandani (Sind)	Do.	Do.
10. M. P. Narsimha Rao (Madras)	Do.	Do.
11. Harbhajan Singh (Punjab)	Do.	Do.

Name	Subject	Date of admission
12. A. R. Braganza (Bombay)	Botany	October 1939.
13. K. D. Sharma (U. P.)	Do.	Do.
14. D. Srinivasachari (Mysore)	Do.	Do.
15. K. C. Batra (Punjab)	Agricultural Chemistry	November, 1938.
16. K. M. Mehta (Jodhpur)	Do.	Do.
17. N. G. C. Iyengar (Mysore)	Do.	Do.
18. Viswanath Prasad (Bihar)	Do.	Do.
19. M. Krishna Reddy (Hyderabad)	Do.	October, 1939.
20. D. K. Patel (Baroda)	Do.	Do.
21. T. R. Goel (U. P.)*	Do.	Do.
22. P. L. Chaturvedi (U. P.)	Entomology	November, 1938.
23. S. N. Elijah (Bombay)*	Do.	Do.
24. C. N. Modewal (U. P.)	Do.	October, 1939.
25. Shamsher Singh (Burma)	Do.	Do.
26. P. R. Bhagwagar (C. P.)	Mycology	November, 1938.
27. A. N. Fotidar (Kashmir)	Do.	October, 1939.
28. S. P. Ray Choudhury (Bengal)	Do.	Do.
29. Miss Sushila Tombat (Madras)*	Do.	Do.

(d) Short Course

Name	Subject	Period of stay
1. M. Pratap Singh (U. P.)	Methods of analysis.	Four months.
2. Raghunath Singh (U. P.)	Do.	Do.
3. R. Bhote (Barwani State)	Pure and applied Entomology.	One year.
4. T. D. Mukerji (U. P.)	Do.	One year.
5. Harbans Lal (Punjab)	Do.	One month.
6. R. D. Saksena (U. P.)	Do.	Two months.
7. Syed Majid Ali (Bhopal)	Sugarcane pests	Do.
8. A. K. Ghosh (Bengal)	Plant pathological technique.	One month.
9. S. N. Banerji (Bengal)	Do.	Do.
10. A. B. Bose (Bengal)	Do.	Two & a half months.
11. B. N. Sinha (Bihar)	Farm management	Six months.
12. H. S. Patel (Alwar State)	Do.	Three months.
13. M. D. Sinha (Bihar)	Animal Husbandry	Six months.
14. R. N. Singh (U. P.)	Do.	One month.
15. H. G. Gupta (U. P.)	Tobacco curing	Two months.
16. K. G. Rajvanshi (U. P.)	Do.	Do.

*Left the course a few days after admission.

(e) Honorary Research Workers

Name	Subject of Research
1. G. S. Murty (Madras)	Vernalisation.
2. A. B. Joshi (C. P.)	Cytogenetics of tobacco, gram and chillies.
3. R. M. Arora (U. P.)	Smut on wheat.
4. J. Thuljaram Rao (Madras)	Anatomy of sugar-cane.
5. Miss P. R. B. Kutty Ammal (Madras)	Anatomy of sugarcane—Bamboo hybrids.
6. Miss B. N. Katrak (Bombay)	Adulterants in <i>ghee</i> .
7. T. K. Ramamurthy (Madras)	Chemical aspects of plant physiology.
8. A. Sen (Bengal)	Drainage experiments.
9. K. K. Narula (Punjab)	Fruit flies.
10. S. Y. Padmanabhan (Madras)	Entomogenous fungi.

APPENDIX III

List of papers published during 1939-40

- Ahmad, Taskhir On the biology of *Euderus lividus* (Ashm.) a parasite of *Agromyza obtusa* Mall. *Indian J. Ent.*, **2** : 59-63.
- _____ The amarantus borer, *Lixus truncatulus* F. and its parasites. *Indian J. Agric. Sci.* **9**.
- Bagavathy Kuttu Ammal, Miss P. R., & Ekambaram. Sugarcane X Bamboo hybrids. *Jour. Ind. Bot. Soc.* Vol. XVIII.
- Bose, R. D. Studies in Indian Pulses, IX. Contributions to the genetics of mung (*Phaseolus radiatus* Linn. Syn. *Ph. aureus* Roxb.) *Indian J. Agric. Sci.* 1939 : **9** : 575-94
- Chona, B. L., and Rafay, S. A. . Natural Transmission and Recovery from Mosaic of Sugarcane. *Proc. Ind. Sci. Cong.* 1940.
- Desai, S. V. Microbiology and Fermentation. *Ann. Rev. biochem allied Res. India*, **10**, 1939.
- Deshpande, R. B. A case of variegation in *Capsicum annuum* L *Curr. Sci.* 1939 : **8** : 313-14.
- Dutt, N. L., and Krishnaswamy, M. K. A note on Photoperiodism experiments on sugar cane at Coimbatore. *Proc. 27th Ind. Sci. Cong.* 1940, Pt. III, Abstracts, 227-228.
- Fernandez, N. P. Nymphomania with sex reversal in a pedigree Sahiwal heifer treated back to fertility. *Ind. Jour. Vet. Sci. & Ani. Hus.*, **10**, 1940, 98-102.
- Ghulamullah Studies on Indian aphididae; I. Aphid fauna of India. *Indian J. Ent.*, **2** : 13-25.
- Hussainy, S. A. Vegetative sports in the bamboo. *Current Science*, Vol. IX, No. 3, 132.
- Janaki Ammal, E. K. Supernumerary chromosomes in Para Sorghum. *Current Science*, Vol. VIII, No. 5, 210.
- Krishna Iyer, P. V. The analysis of asymmetrical experiments with special reference to the partition of treatment sum of squares. *Proc. Ind. Acad. Sci. Sec. A*, II. 1940, 369-375.
- Lal, K. B. Obituary notice—Dr. Walthur Horn. *Curr. Science*, **8** : 384-85.
- _____ Phytopathology—Entomology. *Ann. Rev. Biochem. & allied Res. in India*, **10** : 100-116.
- _____ Some new species of Hymenoptera from India. *Indian J. Ent.*, **1** (3) : 49-58.
- Mundkur, B. B. Taxonomy of the sugrecane smuts. *Bull. Misc. Information. Roy. Bot. Gard. Kew*, No. 10 : 525-533, 1940.
- _____ On *Corticium album* of Dastur. *Curr. Sci.* **9** : **6** : 284-285, 1940.
- _____ Phytopathology-Mycology in 1939. *Ann. Rev. biochem. allied Res. India*, **10**, , 87-99, 1940.

- Padwick, G. W. Note on the Limitation of Infection of Wheat by Ascospores of *Ophiobolus graminis* Sacc. A Possible explanation. *Ann. App. Biol.* : 26 : 4, 823-825, 1940.
- _____ India and Burma; New Plant Diseases in 1938. *International Bull. Plant Prot.* : 13 : 11 : 256-258. 1939.
- _____ A New Disease of Wheat in India. *Curr. Sci.* : 9 : 4 : 179-180, 1940.
- _____ Red-Rot Disease of Sugarcane. *Indian Farming* : 1 : 1 : 32-33, 1940.
- _____ The red-rot Epidemic. *Indian Farming* : 1 : 6 : 263-267, 1940.
- Pal, B. P. A note on the varieties of potatoes grown in India. *Emp. J. Exp. Agric.* 1940 : 8 : 80-84.
- _____ Genes : atoms of heredity. *Indian Farming*, 1940 : 1 : 270-273.
- Pal, B. P., and Nath, P. . . . The Simla Potato Breeding Station. *Indian Farming*, 1940 : 1 : 25-28.
- Pal, B. P., and Ramanujam, S. . . . Asynapsis in Chilli (*Capsicum annuum* L.) *Curr. Sci.* 1940 : 9 : 126-28.
- Pruthi, Hem Singh Ecology and control of insects. *Indian J. Ent.* : 1 (3) : 87-91.
- _____ Description of some new species of *Emppasca* Walsh from North India. *Indian J. Ent.*, : 2 : 1-10.
- Pruthi, Hem Singh, and Nigam L. N. The bionomics, life-history and control of the grasshopper, *Poeciloceris pictus* Fab., a new pest of cultivated crops in North India. *Indian J. agric. Sci.*, : 9.
- Pruthi, Hem Singh, and Bhatia, H. L. A new pest, *Acanthiophilus helianthi* Rossi of safflower in India. *Indian J. agric. Sci.* : 10 : 110-118.
- Ramanujam, S. An apetalous mutation in turnip (*Brassica campestris* L.). *Nature*, 1940 : 145 : 552-53.
- Venkataraman, T. S. Sugarcane X Bamboo hybrids. *South African Sugar Journal*.
- Vijayasaradhy, M. Thermo or Vacuum flasks for preserving sugarcane pollen. *Curr. sci.* Vol. VIII, No. 12, 554-555.

